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The high school science curriculum needs a thorough-going reorganization and the material equipment for science teaching needs modernizing.—THE AAAS COOPERATIVE COMMITTEE ON SCIENCE TEACHING.

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLVI FEBRUARY, 1946 WHOLE NO. 400

MATHEMATICS THE LANGUAGE OF QUANTITY

H. C. CHRISTOFFERSON
Miami University, Oxford, Ohio

Fellow Members of the Mathematics Section of the Central Association:

I send you my greetings from overseas, where for a few months I have been teaching mathematics at the University Training Command in Florence, Italy, to G. I.'s, who are stationed abroad or who are waiting to be deployed. I send you this message at the kindly insistence of your gracious chairman whose invitation to address this section I had accepted last Spring before I was asked to go overseas.

I have an idea which I'd like to emphasize, and I know of no better vehicle for its propagation, dissemination and use than the Central Association of Science and Mathematics Teachers. It is not an original idea, nor a new idea, but like many good ideas it needs to be re-learned, repeated, re-stated, re-viewed, re-newed, and re-applied frequently. To give you a bit of the background from which I now address you I should tell you briefly about our U. S. Army University Training program, especially the U. T. C. in Florence.

The University Training Command has three centers, Florence, Italy; Shrivenham, England; Biarritz, France. Our sessions are for one month and three months, theirs are for two months. My work is in the one-month program, about like a summer session at home. The schools all have two major functions. First, we provide civilian "orientation" to assist in the transition back to civilian life. Our students have been out of school for from one to four years. Some have forgotten how to study. Some have learned how to study and how to get a job

done well and expeditiously. They relish this chance to try themselves out. One man whom I got to know fairly well wisely decided not to go on to school, but to begin business at once. He wants to run a first class night club. Others have found that they really can study and have the confidence and stimulus to go on to school for professional or business careers. The second function of the school is to provide college education, either as refresher courses for work previously done but largely forgotten, or to provide a running start on courses in which they expect to enroll when they return. In my trigonometry class of 29 men, 15 were taking it as a refresher course, 12 as an advance try out and running start on something they thought they wanted and 2 were just shopping around to find themselves vocationally. Possibly a third function that could be admitted among friends, although the commanding officers may not agree, is to provide intellectual busy work for idle men. Maybe other schools serve that function too, even though we are loathe to admit it. Incidentally we have an excellent football team. We publish a weekly college newspaper (*The U. S. Collegian*) and even have a symphony orchestra.

The men who come here, many of them, want mathematics at many levels from high school algebra or geometry, which they may have failed to get, to graduate work in mathematics. Because of limited faculty we have limited our enrollment to those with two or more years of high school mathematics. Consequently we get men who know what they want, most of them serious-minded, good students who know the values of good education in mathematics. This feeling of the G.I.'s that mathematics is vital for many avenues of life has stimulated my thoughts on *Mathematics the Language of Quantity.*

The following incident at our faculty club here provides an analogy. One evening in the lounge a local artist was busy painting portraits from photographs. Dr. Bancroft, another mathematics man from the Central States (Iowa) and I went up to her and I asked, "Do you mind if we watch you?" The young woman artist knew some English but this puzzled her. With a baffled look she said, "mind?" then touched her head, "watch?" and looked at my wrist watch. Finally she shook her head, "Non capisco!" (I do not understand.) She knew one meaning for both *mind* and *watch* yet neither made sense here. This happens frequently in the language of quantity which we call mathematics.

Transposition is taught in some algebra classes. Children learn that when $x+2=10$, then $x=10-2$ or 8. They transpose the 2. Even some G. I.'s have that baffled look when they solve $2x=10$ and find that they now cannot transpose the 2. We teach cancellation with half a dozen different meanings, one of which will enable him to reduce

$$\frac{2a^3x^2}{2x^2} \quad \text{to} \quad a^3.$$

One cancels the 2's and x^2's. Some G.I.'s try to reduce

$$\frac{2a^3+x^2}{2x^2}$$

by also cancelling 2's and x^2's. They get such erroneous answers as a^3+1, a^3, and even $a^3/0$.

Mathematics, our remarkable language of quantity, is a complex, intricate network of meanings and a system of closely related laws and techniques. These have a vast array of applications which make the language not easy to learn yet of great and vital import to modern society. As mathematics teachers we often fail to appreciate that our language is complex, that its remarkable abstractions are amazingly general, and that therefore its applications are so astoundingly varied, boundless and vital.

For example, we teach students to graph a sine curve, that graceful "permanent wave" that starts at zero on the x-axis and rises along a beautiful arc concave downward, to a high point of $+1$ in $\frac{1}{4}$ of a period, ($90°$ or $\pi/2$). It then descends to normal in another quarter period, and proceeds downward in a curve concave upward to -1 and finally back to normal in the full period of 2π radians. The graph of $y=\sin x$ is a beautiful abstraction, in fancy like a graceful dancer waltzing over the floor. It is pure mathematics, fascinating theory, an illuminating picture of how the sine function varies.

A physicist sees this curve and interprets into it an electrical alternating current. $Y=\sin x$ becomes $y=A \sin By$ to make its oscillations more rapid and its amplitude far greater than from $+1$ to -1. The economist sees it and for him it means the price of eggs, but of course normal can't be zero. He changes it to something like $c=40+10 \sin t$, in which $c=$cost of eggs and $t=$time, with 2π being 12 months. The origin is about Nov. 21.

In three months the price will normally rise from the usual level of about 40 cents to 50 cents, back to 40 cents in the spring, possibly down to 30 cents in the summer and back to 40 cents in November again. These constants may greatly need adjustment now. Eggs in Italy cost about 30 cents apiece, not per dozen. Yet, "$C=N+S \sin t$," does something for the economist.

Our abstract theory has become a language of quantity for electrical current and for the price of eggs. With it the physicist and the economist are able better to understand their problems, better to present their findings, and better to discover new relationships and new principles in electricity and economics. The teacher who taught the sine curve possibly little realized how varied and important were the implications and applications of that beautiful bit of abstract theory.

From the first grade on the chief function of mathematics is a language of quantity. The child learns to count things yet somehow acquires a number structure that is abstract. When he adds 2 books and 3 books, 2 blocks and 3 blocks, he soon realizes that $2+3=5$ regardless of what the quantities are. Thus throughout arithmetic,—fractions, decimals, measures, percentage—a language is built which is completely abstract, yet which has a variety and richness of concrete application that staggers the imagination and should make more poets out of mathematicians. Living in Italy I realize how limited are the uses of the English language. Our language of quantity transcends national boundaries with complete freedom. The number system, formulas, the sine curve are the same in U. S. A., Italy, Russia, Japan, or even on Mars.

One more illustration to show concretely the value of abstraction, then an exhortation and I am through. We study quadratic equations and quadratic functions in algebra. Some of us like to let children's imaginations play a bit. We graph $y=x^2$, which is a parabola opening upward with its axis the $y-$axis. What happens if we change the sign of the x^2? Suppose there is an x term, $y=x^2-10x$? Or a constant term, $y=x^2-10x+10$? The x term moves it over and the constant pushes it up or down. Now its axis is $x=5$ and its spread too is changed. Suppose it were changed to $y=10x-x^2$, what then would happen? Well that just flops it over with the hump on top and its legs down like the arch of a bridge.

The arch of a bridge did you say? After all, "That curve is different from a circle and maybe it could be used," thinks

the architect. Experiment shows that it is much stronger than a circular arch. The parabolic arch becomes useful to a builder who wants a maximum of strength for a minimum of material.

Automobile headlights formerly were very glary. Well after all there are other curves than a circle, so, "Lets try a parabola," says an ingenious manufacturer. A light at the focus of a parabolic mirror is reflected in rays parallel to the axis. Presto! Auto lights are less glaring.

The distance a projectile travels upward in t seconds at 100 ft per second initial velocity, the physicist informs us is $S=100t-16.1t^2$. Another parabola, and the artillery men study parabolas to enable them to fight a war. The enemy may not understand English, but he listens attentively to that applied mathematics.

An engineer is constructing a drain which he wishes to surface so as to carry a maximum of water for the least surface. Shall the cross section be square or what shape? Suppose the material standard roofing is 36 inches wide. Then if he turns up x inches on each side the bottom of the trough will be $36-2x$ inches wide. Its area is: $A=x\ (36-2x)$ or $A=36x-2x^2$, another parabola. Graph it or imagine graphing it and you realize that the maximum cross sectional area is obtained when $x=9$ in, or the depth half the width.

This often condemned "useless mathematics," the quadratic function in its graphic form, has been a language by which the architect, the manufacturer, the artilleryman and the engineer could understand the secrets of nature, could discover amazingly new ideas, and could translate them into greater comforts, more security, and finer living.

I told all my classes here that I was writing this paper for the Central Association. I asked them to express themselves on two questions, and promised I'd summarize their statements so as to make them most helpful for mathematics teachers back home. (*1*) *What values have you experienced from your mathematics training?* (*2*) *What shortages were there in your high school mathematics that should be remedied?* I feared that the second question would bring a whole broadside of suggestions. Not one bad condemnation did I get. The worst fault-finding was one man's disapproval of a principal who was supposed to teach mathematics but had to cut the class half the time. Others crabbed because they had not taken trigonometry or because their schools offered so little mathematics. A large majority

said that they had excellent teachers in high school, that they used their training often and appreciated it greatly. I was joyously amazed at the fine sense of appreciation and unquestioned loyalty of these men for the teachers back home who taught them their mathematics. This confirms my conviction which follows.

Mathematics is a subject of vital importance to modern society. Its abstractions, its techniques, its modes of thinking, its laws penetrate widely and deeply into many phases of modern life. As teachers of mathematics we sometimes fail to keep before us this vision. The facts and principles of arithmetic reach from the classroom to the farm and the factory, to the accounting room and the research laboratory, to the engineer, the architect, the designer, whether in Chicago, U. S. A., Italy, England, Russia, Japan, or South America. Knowledge of formulas, how to substitute in them, how to use them, becomes for children a magic key that will be an "open sesame" for many storehouses of treasure. Knowledge of a graph and the way it reveals the functional relationship between two related variables is an instrument to portray pictures such as have not yet been dreamed by the mind of man. Through mathematics we give children a language, not an ordinary language like Greek or Latin or English that may perish, but an everlasting language of quantity, a universal language through whose medium rare secrets can be discovered, a service language whose phrases, sentences and implications can be found in nearly all aspects of life. Let us not lose this vision of mathematics and let us so teach our language of quantity that our students will be able to speak it fluently and confidently.

OUR COUNTRY'S SCHOOLS

According to 1944 data there were enrolled in all schools in the United States:

683,124 children in kindergartens
19,673,376 children in elementary schools
6,923,538 pupils in high schools

We can take pride in our schools but such facts as these show much room for improvement:

. . . 5 million or more children, 5–17, not in school (1940 U. S. Census)
. . . 13 per cent of our adult population have not completed the fourth-grade
. . . fewer students in colleges and universities than there are inmates of prisons, mental institutions, and almshouses.

THE PREPARATION OF HIGH SCHOOL SCIENCE AND MATHEMATICS TEACHERS

Report No. 4. The AAAS Cooperative Committee on Science Teaching[1]

The end of World War II has confronted American education with two highly disturbing facts. The first fact is that the survival of modern civilization depends upon understanding and control of scientific techniques whose power for good and evil dazes human imagination. The second fact is that our teachers and our equipment for teaching this understanding and control are woefully inadequate.

Science teaching in America, particularly at the high school level where the ordinary citizen finishes his formal education, is not ready for the responsibility which it must nevertheless

---

[1] This is the fourth of a series of reports dealing with broad problems of science teaching which require collaboration of representatives of the various sciences. The American Association for the Advancement of Science sponsors the Cooperative Committee on Science Teaching. The members of the Committee, nominated by their respective scientific societies, are:

American Association of Physics Teachers
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Chairman of the Committee
Glen W. Warner, Chicago City College, Wilson Branch
American Astronomical Society
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Raleigh W. Schorling, University of Michigan
National Council of Teachers of Mathematics
E. H. C. Hildebrandt, Northwestern University
National Science Teachers Association
Philip G. Johnson, Cornell University
Morris Meister, Bronx High School of Science, New York City

Former Members of the Committee who participated in the preparation of this report are:
Albert A. Bennett, Brown University
G. P. Cahoon, Ohio State University
Robert J. Havighurst, University of Chicago
M. V. McGill, Howe Military School
Walter F. Loehwing, State University of Iowa
Oscar Riddle, Carnegie Institution of Washington

assume. Nor is education ready in other subject areas for its obligations in an atomic age. The time is short. The task is nothing less than to lift a whole generation of American citizens to a level of knowledge and human goodness which has hitherto been attained only by a small fraction of our people.

Blame for the inadequacy of our teaching of high school science and mathematics belongs with the American public, which has failed to pay its teachers decently, and with the American college and university, which have failed to prepare prospective teachers for the kind of teaching they should do. There are three primary and interrelated problems:

1. Science[2] teachers are not properly trained for the actual teaching assignments they must accept as beginning teachers working for the most part in small high schools.

2. Not enough able men and women are attracted to science teaching in the schools, because salaries are indecently low and the job lacks dignity.

3. The high school science curriculum needs a thoroughgoing reorganization and the material equipment for science teaching needs modernizing.

The Problem of This Report Is Located Primarily in the Small High School

This report deals with the problem of preparing science teachers properly, and especially teachers for the small high schools. Half of the high schools in the country have five teachers or less. Three-fourths of them have ten teachers or less. Yet the small school must offer courses in at least twelve subjects, and many of them offer fifteen to twenty subjects. Although the number of small schools is decreasing, the problem of the small school will remain a large one for many years. Most new teachers commence their work in small high schools because the large schools require teaching experience of candidates for positions. The beginning teacher in a small school nearly always must teach at least three different subjects, and often four or five.[3]

The problems of teacher preparation in the large cities are different from the ones discussed in this report. The school system of a metropolis usually controls the training of most

[2] The term "science" is used in this report to include mathematics. Sometimes to be more explicit the term "science and mathematics" is used.

[3] For a more thorough presentation of these facts, see the Committee's Preliminary Report, School Science and Mathematics, 42, pp. 636–650 (1942).

of its prospective teachers through setting up standards which must be met by local teacher-training institutions, provides assistantships and substitutes' positions to give the beginning teacher experience, and assigns the teacher only one or two subjects to teach. This report will not be concerned with problems which are peculiar to the large school systems, and much of it will not apply to the situation in large cities and in teacher-training institutions which serve large school systems only.

The Nature of the High School Science Program

In the high school science program we must pursue two different goals if science teaching is to make its essential contribution to the welfare of our society. Two recent reports point to these goals. The Harvard Committee's report on *General Education in a Free Society* discusses the need for science in the general education of boys and girls who will make up the bulk of American citizens, some of whom will go on to college, but most of whom will go directly into earning their living from high school. The Bush report on post-war scientific development[4] points out the need for better selection and training of future scientists.

Neither of these purposes of science teaching is now achieved as well as it must be achieved. In the selection and the training of future scientists we fall short of utilizing the best brains of our population. As the report of the Bush committee shows, there are at least as many boys and girls of high ability who do not get a college education as there are in the group who go to college. Thus, much ability goes undeveloped and largely unused. Added to this is the fact that many high schools do an utterly inadequate job of teaching science to students who will specialize in these subjects later.

Equally important and just as poorly done is the task of general education in science. It is a truism that the intelligent citizen must have some understanding of the nature of science and its consequences in modern life. The majority of students in high school need a kind of science course which fits their present interests and their future needs as citizens. Such courses must be well taught to be successful, with thorough treatment of topics taken up and with application to consumer problems, personal and public health, the use and conservation of natural resources, international relations, and so on.

[4] *Science—The Endless Frontier*, Washington, D. C., U. S. Government Printing Office, 1945.

In the small high school the need is for a science teacher who is trained broadly enough to teach the varied science aspects of general education, and who is also well enough trained in one or more specific sciences to teach the prospective scientist the things that will enable him to get started on the path of specialization. This more intensive work of the future specialist should include experimental work in the laboratory, special reading and problem assignments, as well as the work taken by the majority.

The high school science program which the Committee has in mind is one in which all students would take at least a year of general science (possibly in the seventh and eighth grades), a year of biological science, and a year of physical science. The year of physical science might be physics, or chemistry, or a "fused" physical science course. Each of these courses should provide the kind of first-hand experience of natural phenomena that is gained from demonstrations, field-trips, and laboratory experimentation.

Coordination of Mathematics and Science Courses

Because mathematics is essential to understanding science and is becoming the language of science, and because science applications are one of the important uses of mathematics it is particularly desirable that science and mathematics courses be inter-related and coordinated in both the junior and senior high school. Such coordination could be achieved through (a) broad preparation of the teacher so that he can illustrate and use the relationships in his own teaching; and (b) careful common planning by teachers of science and of mathematics. While it obviously is not necessary to include a great deal of mathematics in junior high school or even senior high school science courses, reference to and use of such relatively simple topics as decimals, percentage, significant figures, ratio and proportion, simple equations, squares and square root, and units of measurement are desirable. The teacher should be familiar enough with the various science and mathematics courses so that he can make the appropriate connections in his own courses, even though he may not teach both science and mathematics.

Recommendations

The teacher in the small high school is usually prepared too narrowly by his college for the variety of subjects that he must

teach. To correct this situation, both the college and the state certification authority must move, and move together. The college must broaden the training of the prospective teacher, and the state certification authority must require a reasonable minimum of specific preparation in each subject which the teacher teaches.[5]

Recommendation 1. A policy of certification in closely related subjects within the broad area of the sciences and mathematics should be established and put into practice. Specifically any combination of three of the following five subjects is recommended: biological science (including both botany and zoology), chemistry, mathematics, physics, and general science.

Many colleges have adopted standards of concentration in a major department which make it difficult and often impossible for an under-graduate to secure a good preparation for teaching in as many as three science fields. While this may be appropriate for the future research scientist, it is not good for the future high school teacher. The colleges should provide opportunity for a "concentration" which shall lie not in one department but shall spread (not too thinly) over at least three subjects among the sciences and mathematics. The program for the liberal arts degree should allow for such a program of study.

The Committee proposes this policy as a minimum for beginning teachers. As the teacher gains experience and perhaps looks toward a position in a larger school, he should be required to take further work in the subjects in which he plans to specialize.

Recommendation 2. Approximately one-half of the prospective teacher's four-year college program should be devoted to courses in the sciences. The committee recommends that approximately one-half of the four-year college program should be given to courses in science and mathematics. Sixty semester hours, divided among three subjects will allow for a 24-hour major in one science subject and 18 hours in each of two others.[6]

Such a program allows for a reasonable degree of specialization and insures enough breadth to prepare the student reasonably well for the teaching assignments he may expect during his

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[5] For a more detailed treatment of the desirability and reasons for the present recommendations, the reader is referred to the Committee's Preliminary Report.

[6] When biology is one of the three subjects, the Committee recommends a minimum of 24 hours, rather than 18 hours, because preparation in botany, zoology, and physiology is necessary. When general science is one of the three subjects the wide spread of preparation for this subject will require 5 to 10 semester hours of science above the 60 here suggested.

first years of teaching. This program leaves ample room for the usual "general education" requirements of the college and for the required professional courses in education. For the student who plans carefully and is given advice early enough, it even leaves room for 18 or 20 semester hours of a subject such as history or foreign language or music which a student may wish to take as an extra subject to be added to his teaching repertoire.

The Committee is convinced that progress will be made in the preparation of science teachers only if the science departments consider that this preparation is one of their major functions and treat it as such. There should be a section in the college catalog describing the program for the preparation of science teachers. This program should be worked out cooperatively by the science departments and the department of education. Such collaboration will result in a better solution of the problems of student teaching and of courses in methods of teaching, which the Committee recognizes as an essential part of the preparation of a teacher.

The prospective science teacher should make a study of the social consequences and historical backgrounds of science. This may be done through a thorough-going course in this field, offered for juniors and seniors, through reading and honors work, and through assisting the instructors of college courses of the "cultural" type. Also the prospective teacher could gain much from observing experimental teaching at the secondary level which aims to correlate and integrate the sciences.

Recommendation 3. Certificates to teach general science at the 7th, 8th, or 9th grade level should be granted on the basis of a broad preparation including college courses in all the subjects concerned in general science. Because it provides activities and information relating science to everyday living in our modern technological world, because it cuts across the boundaries of specialized subject matter lines, and because it provides an opportunity for all, or nearly all pupils to explore science phenomena and applications, the Committee recognizes general science as extremely important. It is therefore particularly desirable that a teacher be well equipped to teach such a subject.

The Committee proposes that certificates for teaching general science and not the special sciences be granted only to candidates who have college courses in all of the basic sciences. Exception might be made only in the case of people who show

proficiency in the broad field of general science through some type of examination such as is suggested later in this report.

The Committee's best judgment is that approximately 42 semester hours is an appropriate minimum requirement, with a minimum of 15 hours in biological science, 15 hours in physical science (including both physics and chemistry), and 12 hours in earth science (geology, physiography, meteorology) and astronomy.

The earth sciences should receive more attention in the general science courses. In recent years they have been largely displaced as separate subjects in high-school curricula. The Committee believes that if science teachers had some formal training in that area, there would be a re-introduction of subject-matter dealing with man's natural environment. Never before has the average person had so wide an opportunity of coming into contact with the diverse features of the earth's surface as is afforded him today through our modern means of transportation and never before has intelligent citizenship been so much dependent upon understanding of the earth and its natural resources.

Recommendation 4. Colleges and certification authorities should work toward a five-year program for the preparation of high-school teachers. All of the goals of science education would be better achieved if the prospective teacher had a five-year period of preparation. There would then be more time for obtaining the broad liberal education which promotes growth of the student as a person and makes him a better teacher. There would also be time for both the broad training in science which the Committee recommends and the specialization in one subject which is desirable for the teacher in the larger schools.

The major obstacle to the rapid spread of the five-year program is economic. Most of the large cities and several of the wealthier states now require it. Probably the states and areas with less wealth will not be able to pay salaries which justify five years of preparation until legislation is passed to furnish federal aid toward the raising of teachers' salaries.[7]

Recommendation 5. Curriculum improvements in the small high school should go hand in hand with improvement in teacher preparation. If the teachers of science and mathematics were more broadly prepared, they would still have difficulty in the

[7] For a detailed statement of this thesis, see "On the Teaching of the Basic Sciences," a Committee Report, *American Journal of Physics*, 12, 359–362 (1944).

small high school because the number of students is too few to permit the offering of a variety of courses. No school with less than two hundred students, for example, could offer one course in algebra for pupils going to college and a separate course in general mathematics for those not going to college. Yet variety is desirable—at any rate enough variety to provide a sequence of courses for those planning to specialize in the science area and a different sequence for those who will not specialize, and in most cases will not go to college. When teachers are broadly enough prepared to teach the variety of courses that are needed, ways must be found in the small school to offer these courses.

One way to solve this problem is to teach two courses simultaneously in the manner employed by every teacher of a one-room rural school. Thus a teacher might, in a single period for ninth and tenth grade pupils, teach algebra to one small group and general mathematics to the others. A teacher of physical science might teach a general course for his entire class and add a couple of periods a week for work on problems and for laboratory work in physics with two or three students who plan to specialize in science in college.

A second suggestion is that the college preparatory courses in mathematics be offered in a cycle. Trigonometry and advanced algebra might be taught in alternate years.

A third suggestion involves cooperation among schools, either by sharing students or by sharing teachers. The high school in the county seat might offer Saturday courses for pupils from the smaller schools. Then the local board of education should pay students' tuition and transportation expenses. Two or more neighboring schools might hire some teachers in common, the teachers alternating days or giving mornings to one school and afternoons to another. Correspondence courses are also worth a trial. Local teachers could easily supervise the work of an occasional student in a correspondence course, which should be paid for by the school. Such courses are offered by the extension departments of many state universities as well as by private schools.

A Proposal for a Record of Competence

The foregoing recommendations, if put into practice, would result in better preparation of teachers, but would still give certification to many people who are decidedly inferior in knowledge and teaching ability. Some people would secure

teaching certificates with barely passing grades, with the minimum number of credits, and with inadequate intellectual equipment for the responsibility of teaching. These inferior people would carry the same credentials as the superior ones. Some colleges with inferior standards would turn out prospective teachers with records on paper which were not distinguishable from the records of good students from institutions with the highest standards.

As a means of meeting this situation, the Committee offers a proposal which it hopes will be considered carefully by scientific societies and by state certification agencies. This proposal is *independent* of the other recommendations of the Committee. It is a controversial proposal, and the Committee hopes that people who may oppose it will recognize that they can do so and still support the remainder of the recommendations.

The proposal is to establish a set of *proficiency examinations* and to give a *record of competence* to prospective teachers who take the examinations. The examinations would be designed to test those factors which are of critical importance for successful teaching in the sciences and mathematics, especially such knowledge and abilities as are considered most useful for the high school science teacher. The examination would provide a common standard against which the performance of candidates could be compared, although their preparation may have been in many different colleges. This procedure would supplement the present type of certification requirement. With its aid prospective teachers would be able to give employers a better statement of their fitness for teaching, and employers would be able to do a better job of selecting the best candidates.

This proposal, to be successful, would have to be sponsored by organizations representing several different sciences, since the beginning teacher would seldom have a chance at a position which required him to teach only one subject. A joint commission should be established by these organizations, with power to direct the examination project—to set up specifications for the examinations, to develop tests, and to study results. This commission should consist of high school teachers, college teachers, and test experts.

The examination would cover the broad field of science and mathematics, and possibly the attitudes and skills required for successful teaching, so as to give a profile of the candidate's competence. When the candidate was applying for a position in

general science, for example, an even profile of average height covering the various sciences would be preferable to one that was high in one or two subjects and low in the others. On the other hand, the latter profile might be preferred in the case of a candidate for a position teaching one or two subjects in a large school.

Since the labor of making and administering examinations is so great, the scientific societies would probably not undertake this themselves, but would prefer to collaborate with existing examining agencies. However, new examinations would be required. At present there are no examinations which would be satisfactory for certifying the kind of competence needed by science teachers.

Safeguards against misuse of the examination would have to be maintained. For example, it would not be desirable to require teachers already in service to take such an examination, since their experience in teaching would in many cases give them valuable teaching qualities that could not be measured in the test.

In addition to the use of the examinations as a basis for a record of competence, they could be used for guidance purposes. The prospective teacher at the end of his junior year in college might take the examination in order to find out where to fortify his weaknesses, and the college might use the results of the examination to advise students in the choice of science teaching as a life work.

This proposal for certification of competence is worth careful study. The advantages of the proposal have already been presented. The dangers and difficulties in the way of the preparation of good examinations and of their wise use are well-known. There is danger, indeed, that the remedy might be worse than the disease. Certainly rigid standardization of the content of teacher preparation should be avoided, yet many examination systems have standardized and made too rigid the programs to which they were applied. Such a system should be under continual scrutiny. The teaching record of successful candidates should be studied to find out whether the examinations are really selecting persons who make good science teachers. Any move in the direction of this proposal of the Committee should be undertaken with due caution and in the spirit of scientific inquiry.

Implementation

This report can have good results only if it stimulates leaders in teacher-training institutions and state departments of education to do something about the problems of preparation and certification of science teachers.

In the colleges and universities, it is the first duty of the science departments to seek the cooperation of the department of education. A coordinating committee should be established, with representatives from all the departments interested in the preparation of science teachers. This will insure the give-and-take necessary to meet the realities of preparing teachers for work in small high schools.

State Departments of Education depend upon recommendations from school administrators and from the institutions preparing teachers for modifications in certification procedures. The coordinating committees previously referred to should make their views known to the State Department of Education, and should offer to work with the State Department on certification standards, curriculum improvement in the high-school, and selection and training of science teachers.

The State Academy of Science, and local sections of such organizations as the American Chemical Society and the American Association of Physics Teachers should volunteer to work with the State Department.

Beyond the improvement of certification procedures and of teacher training programs lies a greater necessity and a greater opportunity. World War II has taught the American public that it must support scientific research and the recruiting and training of scientific workers. Money is being provided from public and private sources. Now is the time for science educators to raise their sights and aim for new goals. Better training of scientific workers and the recruiting of brains for work in science require better science teaching in the high schools.

The time is ripe for important developments in science education. This committee hopes now to aid these changes in three ways. First, by studying and reporting on the need for legislation leading to federal support of science teaching in the high schools. Second, by cooperating with the National Science Teachers Association, The National Council of Teachers of Mathematics, The Central Association of Science and Mathematics Teachers, and other organizations in projects for the

improvement of learning and teaching aids in science. Projects are now under way for the development of low-cost laboratory equipment, for visual aids, and for the study of teaching techniques. Third, the Committee proposes to study the procedure for records of competence, with special reference to examinations.

SUMMARY

The Cooperative Committee on Science Teaching has proposed a program for the preparation and certification of high-school teachers of science and mathematics. The Committee has paid special attention to the preparation of the teacher who must begin his teaching with three or four subjects in a small high school. Most beginning teachers find themselves in this position.

The Committee recommends that approximately one-half of the four-year college program be devoted to courses in three of the following science subjects: biological science (including botany and zoology), chemistry, mathematics, physics, and general science. At the same time, the Committee recommends a policy of certification or licensing of teachers for three subjects to correspond with this program.

For certification to teach general science at the junior high school level only, the Committee recommends a broad training in all the basic sciences, with a minimum *requirement* of 15 semester hours in physical science (including both physics and chemistry), 15 hours in biological science, and 12 hours in earth science and astronomy.

A five-year preparation for high school teachers is considered by the Committee to be essential for solution of the problems of obtaining a broad liberal education, breadth of preparation in science, and fair degree of specialization.

The Committee also recommends that scientific organizations consider a plan for *records of competence* of prospective science teachers, through a comprehensive examination specially prepared to test competence in various factors related to successful teaching of science.

That every man may receive at least a moderate education, and thereby be enabled to read the histories of his own and other countries by which he may duly appreciate the value of our free institutions, appears to be an object of vital important. . . .—ABRAHAM LINCOLN

FOOTNOTES ON THE SCIENCE CORE IN LIBERAL EDUCATION

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I. Let us first examine and try to dispose of some current misconceptions as to science and liberal education of today. It is a common saying, if not a common belief that ours is an *age of science*. Ours is more of an age of science than was that of the men of the stone age, or of our forebears of a thousand, ten thousand, or even a hundred years ago. But even today, despite modern biology and medicine, men and women (some of them college graduates) join antivaccination and antivivisection drives. It still pays (in our beloved U. S. A.) to advertise all kinds of frauds in the fields of foods, health, beauty, and what have you? And it is men and women, not gadgets, that give the character to our times.

As the natural sciences provide our only reliable understanding of man and of the universe, these sciences have gradually been incorporated as part of our liberal education. The sciences of physics, chemistry, biology and medicine have given new implications to the old sayings: "know thyself"; "the proper study of mankind is man." But it is not true that the natural sciences dominate (some say: destroy) liberal education in America today. If the nearly 200 colleges and universities of 16 midwestern States studied by me three years ago are at all typical of our Nation, the natural sciences in our colleges make up only about 20 per cent of the college faculties and college teaching budgets. I can only express my grief and regret that so many colleagues do not secure information on this question before they talk or write. We, the teachers, should speak by the card. And according to my best information and experience, the natural sciences or anything worthy of the name science, does not dominate the high school curriculum of our nation either.

This war, owing to the imperative needs of technology, has led to some fears, confusion, and debate both as to our alleged educational failures and dry rot of yesterday, and as to the danger of greater educational errors tomorrow. In much of this debate we are putting the emphasis in the wrong place, on the *plan* or the *system* instead of on the *teacher*. To be sure, there is technology without science, but there is no science without some technology. Why fear skill in any field? There is technology

even in philosophy, in the humanities, and in the social studies. This war has fostered another delusion. We think we are going to have tomorrow not only "one world," but a "new world"! Hence, the tried and true is yesterday's liberal education and will not apply to tomorrow. Yes, a new world, populated by the same old genus *homo*. For history and anthropology reveal that man changes very, very slowly, considering the span of our race. It seems clear to me that we will come out of this war with the same old brain, the same old struggles to survive, essentially the same old mores and values in human relations and in the pursuit of happiness. Here are a few recent samples of this futile and unfortunate debate:

In his recent book, *The Rebirth of Liberal Education*, a study financed by the Rockefeller Foundation, Dr. Fred B. Millett makes the charge that science and the scientific method are the most dangerous foes of the humanities in our liberal education program. President Hutchins appears to voice the same myopic views when he charges that "specialism, which has wrought such wonders in scientific investigation, has promoted the extinction of liberal education. . . . The forces of specialism are constantly whittling down the program of liberal education and deprecating it." But President Hutchins knows, or should know, that specialism, in the sense of the trivial as opposed to fundamentals, is not confined to the natural sciences. There is plenty of specialism and the trivial both in the humanities and the social sciences. And there is little progress in the old past time of the pot and the kettle. And none of us can always be sure that what first appear trivial in the natural sciences will remain trivial. The failure of bacteria to survive in close proximity to certain moulds looked trivial at first, but few informed people would label the discovery of that initial fact *trivial* today.

Professor J. Duncan Spaeth of Princeton University is on the same beam when he says, "The eclipse of the humanities as a result of mobilization of education for total war is but the culmination of tendencies and drifts that have long been operative, and is a symptom of the deep *infection* (italics ours) of our modern, and especially our Western world, with a mechanistic and materialistic interpretation of the nature and source of *power*. It is the victory of the 'law for thing,' over the 'law for man'." But man is also "a thing," subject to the forces and laws of nature. I regret to note that Dr. Spaeth is in the poorly informed group who insists that the natural sciences

dominate modern liberal education. This is simply not the fact. And there does not exist that clear and sharp antithesis between the natural sciences and the humanities outlined by Dr. Spaeth: "Science advances by experiment, the humanities build on experiences. Science . . . creates the knowledge that is power; the humanities . . . create the power that is character. . . . The humanities look backward, the physical sciences look forward." Nor can I agree with Dr. Spaeth that "the humanities are the only efficacious antidote to a narrow nationalism and cultural isolationism." The scientific method is universal. Biology and anthropology have established the essential homogeneity of the present human race. The sciences of medicine, health, and disease cannot be confined by political boundaries. But I am in complete agreement with Dr. Spaeth when he says that both the sciences and the humanities are necessary in "a complete and generous education." However, when is even a "generous education" *complete?*

Granted that some teachers in the natural sciences, as well as some teachers in technology stay too persistently in their special ivory towers, and are relatively ignorant of essentials in other fields of human needs. Granted that a few very competent men in the natural sciences (especially in the stronger colleges) focus even their elementary courses in the direction of specialization rather than on the needs of liberal education for all citizens. The most we can make out of those facts is myopia of a few individual scientists. These facts do not warrant the above sweeping condemnation of science and the scientific method. I cannot agree that training to "carry your own knapsack" is entirely foreign to liberal education. I was trained in my youth to coordinate the hand, the eye and the ear with the brain, to do some tasks (farming, carpentering) necessary for living with speed and accuracy. That training (plus the "classical course" in the American college of 50 years ago) does not appear to have retarded the quest or seriously damaged my mental processes. It may be questioned whether science and the scientific method can make its greatest contribution to liberal education without some technology, a minimum of individual laboratory and field work. But I fail to see that such laboratory and field experience is an enemy of history, sociology, or the fine arts. The goal of the natural sciences is the *understanding of man and the universe.* If the goal of the humanistic educational disciplines in liberal education is the *evaluation of values,* I for one, fail to see any

antagonism between them. Men and women of tomorrow need both. It would be more to the point to put the emphasis on *cultured* teachers rather than on *cultural* courses. Any real evaluation of "values" calls for some understanding of man. The understanding of man and the rest of nature should by itself create some "values."

II. What is, or should be, the minimum core of science in liberal education? If we can find it, if we can agree on it, have we the men and the means to make it effective?

1. I think most educators will agree that this core must include: (a) mastery of the scientific method, the principles of experimentation, and controls in experience; (b) the fundamentals of human biology in health and disease; (c) the fundamental forces and processes in the universe. All these things, not on the basis of the guesses or the philosophies of the ancients, but derived through application of the methods of science.

2. On the college level, as well as in the high school, the time required to attain these goals will vary with the teacher as well with the student. But I think that this science core would not greatly crowd the offerings in the humanities, especially if the science teachers could inspire their students to work, that is, use all their mental abilities to the utmost. It should be equally clear that these goals may be successfully approached by different plans and set-ups in different institutions. The plan or plans are of secondary importance, the teacher or teachers are of first importance. The general science courses for all college freshmen have gotten results in the University of Chicago. But the same plan, with different teachers, has failed in some colleges. It is clearly up to the genius of each college faculty. College administrators should not try to impose on the faculties any plan by fiat. The teacher must be convinced that the experiment is worth trying. Then, and only then, does it become an educational experiment.

3. In a recent 62 page report on the educational problem of the world today the British Association for the Advancement of Science points out that science in general education should not be as strictly compartmentalized as are the natural sciences in the training of specialists and technologists. "The study of natural science (in general education) must be wider than any of the specialists science schools: e.g. chemistry and physics should be taken together as part of 'physical science,' and general biology in place of separate treatment of zoology,

botany, and physiology." This is essentially the type of courses in the Physical and the Biological Sciences required of all freshman students in the University of Chicago during the last 15 years. I agree with our British colleagues that we do ***not*** have enough teachers trained to give such courses adequately. But I cannot agree with them when they say that because "few teachers in history, economy, and language have even a passing acquaintance with the natural sciences and the scientific method," and "few scientists have a good grasp of social problems": students in the humanities should not be compelled to take courses in the natural sciences, and students in the natural sciences should not be compelled to take courses in the humanities and the arts. Educators who wait for utopia are obstructing progress. When we are sure of the goal, we can try for it, even with the aid of crutches.

4. So far I have spoken as if the liberal education of our fellow citizens was primarily or exclusively a concern of the colleges. This is, of course, not the case. This education at the high school level is even more important than at the college level, for the high schools reach more students. And as to the mental maturity or immaturity of our high school population, I am certain that a large part of the high school students can master the above science core, had we the facilities, the vision, and the men and women who could really teach it. I speak not without experience on this point. For more years than I care to state I have endeavored to teach (let my students say how effectively) the dynamic biology of man to (a) college freshmen; (b) medical students; (c) graduate students. When you get your students' real attention and interest their mental capacity is equal to the task at either and all of these levels of mental development. Of course, I admit that the dynamic biology of man has the advantage that, here and there, it contacts and clarifies the student's own experience. I have always felt a responsibility to college freshmen in this field. For without a clear understanding of man in health and in disease even college trained men and women are but "sitting ducks" for the thousand and one varieties of medical and social quackery that feed on the ignorant.

5. The college teacher, like other people, can readily become a creature of habits and a worshipper of the past, including the sacro-sanct liberal education curriculum on which he may have labored for a quarter to half a century. Science has indeed

disturbed the traditional humanities, not so much by crowding the curriculum as by questioning ancient and easy answers and interpretations. Science bows to no man, not even to the "hundred great books" of the past. Yes, science is an iconoclast, a disturber of faiths and dreams, a challenger of nostalgia. But science is a product of man, and science changes significant parts of man's environment faster than does raw nature. Science creates new problems important in the lives of all the people. The science core in liberal education must provide an understanding of these changes and problems lest we perish.

THE DIRECTION OF THE ELECTRIC CURRENT

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Confusion between current and electron flow has long upset the calm of the electricity class. It has been a source of constant amazement to note the number of supposedly informed persons with the oddest notions on this subject. Among army personnel where military training teaches self-assurance, these strange notions are often stubbornly defended. To eliminate vacillation or uncertainty, which is highly unmilitary, army schools have taught one interpretation and banned the other. At one school the word electron was outlawed. It was never to be mentioned in class. At another equally prominent school all principles were taught in terms of electrons only. It soon became customary to feel sorry for those backward individuals who had to use current.

To alleviate the sufferings of our bedevilled teacher of electricity I propose the following device:

1. Define current merely as the direction of decrease of positive potential in any circuit external to a potential source. (Language should of course be simplified to meet the level of the student.) Emphasize the fact that this term was agreed upon as a convention by world scientists of a previous century for convenience of discussion and of expression of electrical principles such as the "right hand rule," etc.

The actual existence of electrons was discovered later. They are a material substance. Their weight has been measured.

2. It will be found that the visual and mechanical minded view the above abstraction with much apprehension. It leaves them definitely unsatisfied. To help these, an analogy can be used: Imagine the current to be a shadow cast by an object in front of a light source. The light source represents the electrons. If the object is stationary and the light source is moving, the shadow will move in the opposite direction. Emphasize the fact that the light source is a material substance, but that the shadow's motion is more like an abstraction, since nothing material moves.

Fibre peg material made with animal glue is now used for fasteners in the manufacture of shoes. The fibre which is lighter than steel is specified by the Quartermaster Corps for governmental shoes. It is also used in safety and work shoes today.

HISTORY OF ALGEBRA

II

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We closed the broadcast last week in the midst of a discussion of the efforts of men to invent better symbols for use in algebra. In their efforts to get a set of symbols that would make algebra work speedy and simple, scholars tried out many ideas. Some ideas that seemed good in hand-written books soon passed out after the invention of printing because it was hard or impossible to set up in type symbols that were easy to write. Another reason for so many changes in symbols was that men were always trying to find symbols that would more naturally express the meanings they wanted to indicate, and as they came to have a clearer understanding of meanings, it was natural that they should change the symbols. This is illustrated by the case of fractional exponents. This is one of the most natural ways of indicating powers and roots, and yet men had to clear up their ideas about these things before the fractional exponents could be adopted. Just over 350 years ago a Belgian by the name of Stevin first used fractional exponents as we do, but it was a long time before his idea was widely adopted.

Our equal sign was given to us by an Englishman named Recorde about 400 years ago but he made his sign about 5 times as long as we make it.

Our plus and minus signs were first used in print about 450 years ago by a German named Widman. We are not sure where he got the idea. Because they are simple and easy to make, they were soon adopted by other writers.

Both the cross and the dot to indicate multiplication are more than 300 years old. The German mathematician Leibnitz objected to the cross because it was easily confused with x, a confusion that you have no doubt experienced.

Our division sign is newer than any of the others, having been used only about 250 years.

In solving linear equations, mathematicians used to use arithmetic rather than algebra, but about 400 years ago a Frenchman whose name was Peletier proposed that they be done by algebra and his idea is now accepted by all.

It has been pointed out that the Greeks solved second degree or quadratic equations by geometry and that the Hindus and

Arabs had several special ways of solving them. Our method of solving them by the quadratic formula was first used by Stevin 350 years ago. Our method of solving them by factoring was used by an Englishman by the name of Harriot about 300 years ago.

An interesting question is whether there will yet be any changes in our way of writing algebra. I think there will, because our present symbols sometimes confuse us. For example, when we use a dot to indicate that 2 is to be multiplied by 3, it is easy to place it a little low and make it look like 2 and 3 tenths. Some symbol other than the dot for multiplication might help here. Another example of confusion was pointed out by Leibnitz 300 years ago. When we use the cross to show that a is to be multiplied by b, it often looks like $a \times b$. Some improvement could be made here.

About the end of your first semester in high school algebra, you learn how to solve two or three equations together and find the values of two or three unknown numbers. This topic is fairly recent in the subject of algebra, and you may wonder how they were able to solve algebra problems in olden times where there were several unknown numbers. The answer is that they usually expressed the second and third unknowns in terms of the first, and thus had no need for simultaneous equations. Even today problems that we usually solve by using more than one letter can be solved with one. Why, then, do we use more than one letter and more than one equation? The answer is that it is sometimes much easier and more direct to use several letters than to use one and express all unknowns in terms of that one. The Hindus found several equations easier than one, and used the names of colors to indicate different unknown numbers. They wrote the different equations one under the other much as we do. The Europeans used only one letter until about 400 years ago when a man by the name of Buteo used several letters and solved sets of equations by addition and subtraction just as you learn to do.

One ancient method of solving equations in algebra was called the rule of false position. This method was in use for many hundreds of years, and only passed out of the books about 400 years ago. It was a method of guessing at the answer and then making the necessary correction to get the right answer from the incorrect guess by using a simple rule.

The idea of graphing equations as we learn to do it began

with the discoveries of a Frenchman by the name of Descartes. In 1637 he published a book on geometry in which the method of graphing was explained. He showed how to use a system of coordinates and locate points about as we do. Some of the ideas he used were known to the Greeks a long time ago and to other peoples also, but Descartes was the first man to devise a complete system for graphing equations. The whole subject of analytic geometry which some of you will study in college is based upon this method devised by Descartes.

In its simplest form, the principle of determinants is merely one more way of solving sets of linear equations. About 250 years ago a German by the name of Leibnitz, one of the inventors of the calculus, used determinants to solve sets of equations. A hundred years later a number of men studied determinants, laid down laws for using them and showed how to apply them. The word ***determinant*** was suggested by Gauss a little over a hundred years ago.

Imaginary and complex numbers which you find in advanced high school algebra have been in use only about 300 years. The Arabs, the Greeks and the Europeans of the Middle Ages naturally had to take into consideration situations where such numbers are met, but they always avoided using these numbers and even avoided recognizing them. 400 years ago an Italian by the name of Cardan was challenged to find two numbers whose sum is 10 and whose product is 40. He correctly solved the problem and checked his results, as no doubt you can easily do after you have finished first year algebra. But Cardan had to make use of complex numbers which no one at that time recognized as proper numbers. Cardan used them, but he called them fictitious. For a long while after that, mathematicians continued to call these numbers fictitious, impossible or imaginary. One mathematician said, "They are neither nothing, nor more than nothing, nor less than nothing, and so they are not numbers at all." Of course, we know better than this now. We even use these numbers in electrical engineering, and so they are quite practical. About 250 years ago, an Englishman by the name of Wallis said imaginary numbers are no more unreasonable than other numbers. Then the Norwegian Surveyor Wessel showed how to graph the numbers as we do today, and from that time to this they have been in good standing.

The subject of probability which you meet in advanced algebra, either in high school or college, had its beginning in the

consideration of problems of gambling, although its applications today are to situations much more practical and worthy, such as life insurance or physics. Two French mathematicians, Pascal and Fermat, wrote letters back and forth to each other over a long period of time discussing probability. Out of these letters grew the subject of probability as you find it in your books. There is no subject in mathematics on which men found it harder to agree in simple fundamentals than in probability. The best mathematicians often contradicted each other and arrived at very different conclusions. However, that is all past, and today the subject is as scientific as any other in the books.

The subject of logarithms has a history wholly different from that of any other in the algebra books. All other subjects were the result of a long period of development with many men of many countries making contributions until the subjects were finally completely developed. On the other hand, logarithms were the invention of a single man, John Napier of Scotland. He had but one purpose in inventing the logarithms, and that was to make easier the long calculations necessary in the study of astronomy. Napier got his idea by comparing the lengths of two lines and had never heard of exponents for the simple reason that there were no such things as exponents in his day. Today we say a logarithm is an exponent, for it turns out that that is just what it is. In his castle in the north of Scotland, Napier invented the logarithms and published his book before anyone knew logarithms existed. Then the greatest mathematicians of the world tried to out-do each other paying homage to Napier. All this attention seemed to embarrass the old Scotchman, and he seems never to have realized fully the importance of his work.

One of the dramatic stories connected with the history of algebra is that of the discovery of the method of solving the cubic or third degree equation. In order to appreciate the story connected with this discovery it is necessary to keep in mind that 400 years ago, a man who knew something about mathematics that others did not know did not usually tell of his discovery or publish his findings. It was common at that time for mathematicians to challenge each other to contests, much as prize fighters would do today. If one man knew something no one else knew, he was likely to challenge his prominent rivals to contests and use his knowledge to win. 400 years ago, one of the subjects that furnished occasions for such contests

was the third degree equation, that is, an equation in which the letter has an exponent 3. An Italian professor of mathematics named Cardan had mastered all that was commonly known about third degree equations, or cubic equations, as we call them, and had added some ideas of his own. Another Italian by the name of Tartaglia had also learned all he could about them and had a few tricks of his own. When Professor Cardan heard that Tartaglia knew a lot about cubics, he challenged him to a contest. Tartaglia accepted. After the challenge and acceptance, each of these men found out that the other knew more about the subject than he had realized, so each set about preparing for the contest by trying to make new discoveries. Cardan did not learn any new facts and decided not to appear at the contest but to send one of his students whom he had trained for the event. A day or so before the contest, Tartaglia had the good fortune to discover a method by which he could solve any cubic equation proposed to him. In all the history of mathematics, no one had ever known how to do this although many men had tried to discover the method. On the day of the contest, Tartaglia and the student each gave the other 30 problems to be solved, then they went away for a few days to work at them. Within a few hours, Tartaglia solved his 30 problems, but the student was unable to solve any given by Tartaglia.

When Cardan heard of the result of the contest, he begged Tartaglia to tell him his method. Tartaglia gave him some hints and Cardan soon mastered the whole process which he published as his own. It has only been in recent years that we have come to know that Tartaglia was the discoverer.

Soon after this, mathematicians learned how to solve fourth degree equations and at once tried to solve fifth degree equations. However, no one has ever been able to find a way of solving the general fifth degree equation, and now we know no one ever will, for this general solution is impossible, just as the trisection of an angle by straight edge and compasses in geometry is impossible. Also it has been proved that is it not possible to solve any general equation of degree higher than the fourth.

This short history of algebra should make it clear to you that mathematics grows year after year by the combined discoveries of many men of many lands. The Egyptians, the Babylonians, the Arabs, the Hindus, the Greeks, the Germans, the English and the Americans have made their contributions. And the

subject still presents many questions to be answered and many problems to be solved. Perhaps you will some day make your contribution to this growth of algebra. It is not at all impossible. But before trying to solve any of the unsolved problems in the subject, your first task is to master what is already in the books, beginning with high school algebra.

THE QUIZ SECTION

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1. If 12 men tool 150 pieces in 20 days, working 6 hours per day, how many days will it take 15 men working 10 hours per day to tool 250 pieces?
2. Quickly now! Two books cost $1.10; one costs one dollar more than the other. What was the cost of each?
3. Most of the ocean water is in the southern hemisphere. (T or F)
4. Where is the center of gravity of the earth-moon system?
5. Identify: (a) Saros (b) Synodic period (c) perigee.
6. The *shape* of the earth has something to do with a body weighing less at the equator than at the poles. (T or F)
7. It can be shown that the tide-raising effect of the sun is about five-elevenths that of the moon. Show, therefore, that the ratio of the maximum joint effect to the minimum is roughly 8 to 3.
8. A drowning man would do well *not* to wave his arms but rather keep them submerged for the added buoyant effect they provide. (T or F)
9. Is there any danger in smoking near a storage battery while the battery is charging?
10. Where is a degree of latitude longer, at the equator or at the pole?
11. A probability of unity corresponds to certainty. A probability of zero corresponds to what?
12. The earth's orbital velocity is at its minimum about July 1. (T or F)

ANSWERS TO THE QUIZ SECTION

1. 16 days; 2. $1.05 and $0.05; 3. T; 4. 2,900 miles from the center of the earth; 5. (a) Interval between similar solar eclipses (about 18 years, 10–11 days); (b) Interval between successive oppositions, conjunctions or similar elongations; (c) Referring to the moon, its position of minimum distance from the earth; 6. T; 8. T; 9. Yes, free H is given off at the negative plate. 10. At the pole; 11. Impossibility; 12. T.

WE SPEND THE LEAST ON THE MOST

Although rural children constitute more than half of the children in the nation, only a little more than a third of the money spent for education is for support of rural schools. . . . The average annual salary of the rural teachers in America is less than half of the average annual salary of teachers in the larger towns and cities. . . . The average rural school spends $84 per year per pupil compared to $122 in town and city schools.

SCIENCE AS A FIELD OF TRAINING IN THE BASIC LANGUAGE SKILLS*

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Whatever other descriptive terms we may use to identify or describe our present age, one term we will agree, will apply. This is indeed the "Scientific Age." Within the last quarter of a century, and particularly within the last five years, the achievements of science have been so rapid and astounding as to leave us wondering what is going to happen next. In earlier years the average citizen was inclined to be very skeptical of the pronouncements of the scientist. Skepticism, however, has given way to amazement and wonder. Mr. Average Citizen is mentally "groggy." "Buck Rodgers" and "Superman" are realities. "But there are more and greater things to come," say scientists. "We are merely on the fringe of discoverable phenomena." The truth of these claims we no longer doubt. This is indeed an amazing era in which we live.

As a consequence of this technological advance, two deplorable results appear. One is the condition of *confused thinking* everywhere apparent; the other is its natural counterpart, *fear* for the future and its possible developments; and *fear* of mankind's inability to cope with his amazing new knowledge.

This confused and irrational thinking is a product of ignorance, in the sense of a lack of knowledge and understanding. There are so many things people do not know; hence they cannot understand. What they do not understand they fear, and a kind of mental paralysis results from such fear, barring satisfactory and needful adjustment to technological changes.

Scientists and inventors promise us innumerable "Better things for better living," but they do not tell us how to make a more satisfactory adjustment to the life we must live in relation to the products of science. Social living has been and still is profoundly affected by the "better things" which science has produced. We have at our disposal the means for better living, but we have not found how to use them in the most useful and constructive way. Unless we do find the way to better living and set out resolutely on that way, we can expect future generations to suffer for our failure.

* Read before the General Science Section of the Central Association of Science and Mathematics Teachers, November 23, 1945.

It is at this point the educator may find his proper place. The school can become strategic ground for better scientific training of young people. As a consequence, better understanding and more satisfactory social adjustment will follow.

However, before the confused and irrational thinking can be clarified, and science, its theories, principles, and application understood, a language barrier must be overcome. Scientific language is a foreign language to the common man. There must of necessity be a more direct and effective means of communication between the scientist and the consumer of his products if there is to be understanding and successful living. The scientist and the teacher must do the major task in removing this barrier to understanding.

An outstanding example of present day scientific ignorance and its resultant misunderstanding centers about *atomic energy*. Since the publication of information about the use of atomic energy in war, there has been, regarding its development and use, a wide variety of reactions ranging from radical statements based on religious convictions to expressions revealing utter indifference. People understand steam power, electric energy, and explosive gases, at least in part, because of their wide experience with such phenomena. However, "The Energy of the Universe" they do not understand; hence they fear it. What people fear, they avoid. Avoidance of the unknown may take many forms not the least of which is stubborn rejection.

But science marches on! Its progress will not be stayed by ignorance or rejection. New and more fantastic revelations will be made in the future. For social adjustment to that time youth must have some preparation.

Among the many tasks the educator has is the highly important one of assisting the youth to develop adequate and more efficient means of communication between himself and those about him. Of these various means one, because of its universality, is of paramount importance. I mean *speech, written* and *oral speech*. The transmission of ideas from mind to mind must be free, uninterrupted, and clear. Such communication is vital to the development of understanding and the acquisition of knowledge.

In this connection the science teacher has an unusual opportunity. In teaching boys and girls to read, speak, and write scientific language, directed practice is necessary. The reading skill is indispensable; knowledge, scientific or otherwise, is of

little value unless it can be communicated to others. It is a safe conclusion that the youth must be able to read well in order to learn! He must be able to speak and write well in order to communicate what he has learned. Thus we come to the fundamental task of the educator, to aid those we teach *to read* well and *to express* themselves effectively. The subject matter in every course is the material with which he works.

In former years it has been the general practice, as it is in most schools today, to place on the "English" teacher *all* the responsibility for teaching reading and expression. It is my conviction that the practice of such a plan is unfair to both pupil and teacher and is relatively ineffective as measured by the progress a pupil can make under a proper program of instruction.

In the Illinois English Bulletin, Vol. 29, No. 2, issued November 1941, by the Illinois Association of Teachers of English, Professor Potthoft observed that, "English instruction (meaning language arts) is dependent upon the willingness of the entire faculty to accept a share of responsibility—that it is beyond the power of the English Department to maintain standards by itself alone." He was speaking in particular of the work in language arts in the University. His statement, though, is applicable to any school.

In the same bulletin two other writers assert that *all* teachers are responsible for training in basic language skills. One quotation: "It is generally conceded that every teacher should be a teacher of English. Unfortunately our teacher training institutions and certificating agencies have not yet managed to develop enough teachers with the desired philosophies and abilities so that all teachers will place the desired emphasis on English in all classes. A real need is that of providing a sufficient number of teachers who are in agreement with respect to minimum essentials." Another quotation: "Too often, in the past, many of our high schools evidently have assumed that the problem of teaching youth to use the English language effectively was the sole duty of the English Department in the school and have proceeded in the theory that the student given the proper books to read, and *forced* to read them, whether he was interested in the subject matter or not, would naturally acquire good and effective usage. One problem is that many of our schools have failed to realize that teaching youth to use the English language effectively is a part of the work of *every* department in school—

that each department should be constantly interested in four important phases of the problem: first, reading effectively; second, thinking effectively; third, speaking effectively; and fourth, writing effectively."

It is the responsibility then of every teacher to participate directly in the work of teaching basic language skills. It should be recognized that unless the pupil can *read* the language of his course, he cannot *learn*. Unless he can *express* himself adequately, he cannot impart to others the fruits of learning. In a world of knowledge he will be curiously and tragically helpless.

In suggesting a better way of training in the basic language skills the following facts should be considered:

1. The results of instruction in language usage in the secondary school fall far short of a reasonable expectation. The indifferent language environment from which most high school pupils come, the radio, the comic strip, the movies, and the language influence of daily associates are more influential in moulding and fixing habits and skills in expression than are the customary courses in high school.

2. There is evidence that instruction in formal grammar has little influence in making substantial improvement in written and oral expression.

3. Compulsory training in language usage has not achieved the results hoped for. Instead of the blank regulation for instruction as in the past, individual guidance is the more effective procedure in developing proper habits and skills in reading and expression. In most classes there exists a wide range of individual differences in ability. Pupil interests vary widely. Some have excellent creative power; some have very little. Some have little concern. Some are good readers; some are very poor readers. The same training for all will not suffice.

4. It is the general practice for only *one* teacher of the four or more the pupil meets daily to be concerned with the obligation of developing proper habits and skills in language usage. There is little carry-over from formal usage instruction in composition to written and oral expression in other subjects. It is obvious that *every* teacher must be concerned with training in basic language skills if the pupil is not to leave school indifferently prepared for the obligations which later will be imposed on him by inescapable social demands.

5. Language usage is a skill subject rather than a content subject. It is not so important that a pupil *know* all the correct

grammatical relationships as it is that in speaking and writing he *employs* correct forms, *spells* correctly, *pronounces* words correctly, *enunciates* clearly, *converses* entertainingly and intelligently, and otherwise meets the educational obligations that society rightfully imposes on the product of the schools. This effective communication is to be achieved by constant and persistent attention to correct forms in all subjects and courses of the school program.

6. Improvement in speech must develop through *all* the experiences of the pupil. Every influence in the school must be in harmony to form a favorable environment in which desirable habits and skills may develop. We really do not "teach" the pupil very much. He will learn regardless of what we may do. *What* he learns depends for the most part on the experiences which the pupil is afforded during the learning period. The best we can do is to set up a favorable environment in which the pupil may learn. We can control the environment, the experiences of the child, and thereby direct his learning.

7. What was once regarded as the exclusive content and method of the "English" course of study is found in all subjects in the curriculum. *Supplementary reading* in all subjects is as important as the matter in the text book. Science is made more interesting and understandable by reading *biographies* of great scientists. Similarly, *usage instruction*, the work which was formerly the sole responsibility of the English teacher, should be a part of the instruction in all subjects. The *composition* or written reports should be read and carefully checked by the teacher if the proper job of teaching is done. It follows then that in all subjects handwriting must be legible; spelling must be correct; sentences must be complete, sensibly punctuated, clear, and definite in meaning; diction must be specific and appropriate to the subject if the work is to meet acceptable standards.

II

In the development of such a program of training in the language arts as I have just outlined certain basic principles are needed both as objective and as guide for training. The following principles are generally recognized by teachers engaged in training pupils in the basic language skills.

1. The business of education is to train pupils to think.
2. The primary tools of thinking are words—words with meaning.

3. A pupil then to think effectively must be equipped with proper tools—sufficient words.
4. Words, symbols of ideas, become meaningful only through experience.
5. Ideas, and information, unless shared with others, are of little value.
6. Oral and written expression are the means of sharing.
7. An immediate objective of training in the basic language skills is to enable each pupil to become articulate in communicating his ideas and knowledge to others, in expressing himself in an effective manner, approved by his group and satisfying to himself.
8. Training in the technics and skills of expression are necessary for effective and satisfying expression.
9. It is the primary task of the teacher through guided experience, to encourage proper habits of speech and to develop skill in expression.
10. A desire on the part of the pupil is highly important to insure improvement in speech habits and skills.
11. Every teacher must engage in directing the training of pupils in written and oral expression.
12. All the influences of the school must constitute an environment favorable to the development of proper language skills.
13. A pupil is largely the product of the home, school, and community.
14. The teacher must never forget that his best chance for instruction is in good example, that he is professionally obligated to use *cultivated speech.*
15. Knowledge, patience, and persistence are indispensable in any program of teaching the basic language skills.

III

In the foregoing discussion two important facts are emphasized, (1) the need for a comprehensive training program in the basic language skills and (2) the establishment of basic principles to guide the program.

In training pupils in the language skills no more productive field is available than that provided by studies in science. Particularly for pupils at the junior high level what is regarded as "General Science" is most strategic. It is well known that pupils read freely *what is interesting*, speak freely about what is in the

range of personal experience, and write more effectively about *what they know best* and find interesting.

Few pupils are unfamiliar with scientific phenomena. That which years ago was puzzling even to the learned mind is now commonplace. The child does not know all the scientific principles of radio, but many a boy can repair and even build a radio when given the parts. There are many home chemical laboratories. The whole field of scientific phenomena in some way or another, comes into the environment of young people. Interest and personal concern are daily intensified. No area of learning is more aided by present environment than is science. Curiosity, the lure of the unknown, is progressively stimulated by pictures, exhibitions, displays, demonstrations, and published reports. The mind of youth is stirred daily by the swift succession of events. The imagination is daily and hourly challenged by new knowledge, new discoveries, new ideas, and predictions of things to come. What a rich field of material for training boys and girls to read, to think, to speak, and to write!

One of the particular handicaps of the "English" teacher in oral and written composition is the fact that materials employed in teaching basic language skills, for the most part, are too remote from the native interests and daily experiences of the child. The teacher may employ the plan of having the boy write about some subject relating to science, but the "English" room is not the science laboratory. The setting is an unfamiliar and remote one. The youthful mind is not stimulated by such an artificial situation; hence his composition is likely to be stilted and formal. The ease and freedom of expression the teacher desires to see is too often lacking. But to go to the science class and witness the freedom of discussion under a stimulating and capable teacher when an interesting experiment is under observation. There may be some incoherence and disjointed speech, but there is *interest* and *unforced* participation. The teacher has an ideal situation for teaching language as well as science. The stimulus to action is there. It is the opportunity, the obligation, the responsibility of the science teacher to see that pupils form correct habits of speech, acquire skills for effective writing, and have ample opportunities for written experience. The teacher must guide action until habits and skills are effectively grooved in the channel that leads towards a desirable goal.

The implacable rule of science is *accuracy*. There must be no

guesswork. Every statement must be supported by facts. Facts must be clearly and positively demonstrated. A theory is only a theory until it becomes a fact. The scientist is a seeker after *truth.* He has a passion for truth. What is hidden must be revealed. Every phenomena must be explained. He has the utmost contempt for superstitition and unfounded dogma. For him all truth is sacred. There are to be no dark corners in life. For him there cannot be the silly conclusion that there are secrets in the universe man must not know.

Fear is lack of knowledge. Knowing the blight that fear can bring, the scientist serves his fellow by dispelling fear and bringing light where darkness is. Thereby he not only develops his capacity for discovering knowledge but also qualifies himself as interpreter of that knowledge. Since the vast majority of people are consumers of knowledge rather than discoverers of it, the scientist must be able to reveal his findings in language people can understand. The scientist must qualify the consumer for effective communication if both are to profit by revealed knowledge.

It seems imperative then that the science teachers must first of all be teachers of basic language skills if the whole job is to be done. If the child cannot read well, he cannot learn what the scientist has to reveal. If he cannot speak and write well, he cannot reveal to others what he has learned. The pupil learns the language of science in the study of science. It has never been and is not now the obligation of the English teacher to do this work for the teacher of science. To place the obligation for poor reading in science, poor spelling in science, poor expression in science, on the English teacher, is inexcusable. This statement holds equally true in every subject field. The development of language ability in any particular subject is the *whole responsibility* of the teacher of *that subject.*

It may appear that a program which places responsibility for training in basic language skills on *all* teachers is too difficult to administer. There is the barrier of common practice. There is the barrier of academic tradition. There are teachers indifferent to standards of expression because they have not been held responsible for maintaining high standards. It seems just as reasonable to require teachers to maintain high standards in language arts as it is to require high standards in subject matter. Basic language skills must be upheld if we are to make appreciable progress in education.

One fact is paramount in any educational program. Teachers and administrators must recognize and accept the fact that education is an all-round, comprehensive activity involving the whole child—his health, his morals, his speech, his abilities, his personality. Every teacher must take account of the child as a unit. Instruction must be based on this concept if education is to be effective.

A GEOMETRIC DERIVATION OF FORMULAS FOR TAN($\alpha+\beta$) AND TAN($\alpha-\beta$)

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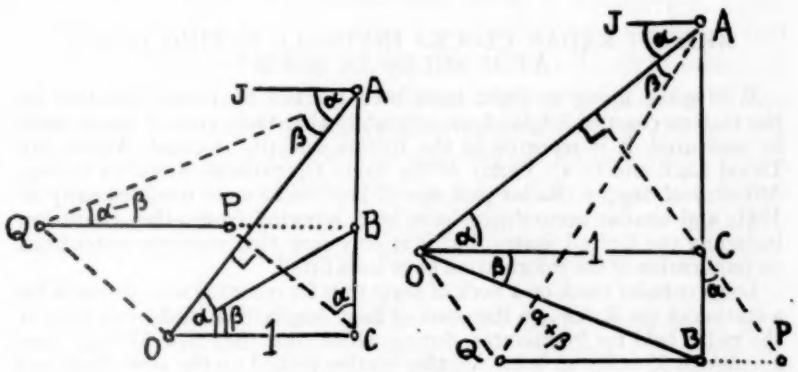
Here is a derivation of the formulas for tan $(\alpha+\beta)$ and tan $(\alpha-\beta)$ in which the diagram shows the very terms and combinations that appear in the formulas.



Both diagrams are constructed upon a line OC, of unit length, with the angles $AOC=\alpha$ and $BOC=\beta$. A and B lie on a line perpendicular to OC at C, and through them are drawn AJ and BQ parallel to OC. Then P and Q are located on the parallel through B by drawing CP and OQ perpendicular to OA.

In both diagrams we have

$$QP=1$$
$$AC=\tan\alpha$$
$$BC=\tan\beta$$
$$OA=\sec\alpha$$

$$PB = BC \tan \alpha = \tan \alpha \tan \beta$$

$$OQ = CP = BC \sec \alpha = \sec \alpha \tan \beta$$

$$\tan QAO = OQ \div OA = \tan \beta$$

$$\angle QAO = \beta$$

$$\angle JAO = \alpha.$$

In the two diagrams, we have on the

left:	right:
$\angle AQB = JAQ$	$\angle AQB = JAQ$
$= JAO - QAO$	$= JAO + QAO$
$= \alpha - \beta$	$= \alpha + \beta$
$\tan(\alpha-\beta) = \dfrac{AC-BC}{QP+PB}$	$\tan(\alpha+\beta) = \dfrac{AC+BC}{QP-PB}$
$= \dfrac{\tan\alpha - \tan\beta}{1+\tan\alpha\tan\beta}$	$= \dfrac{\tan\alpha + \tan\beta}{1-\tan\alpha\tan\beta}$

BRITISH RADAR CLOCKS INVISIBLE FLYING GEESE AT 35 MILES AN HOUR

Wild geese flying at night have been tracked by radar operators on the eastern coast of England, so accurately that their ground speed could be measured, it is reported in the British scientific journal, *Nature*, by David Lack and G. C. Varley of the Army Operational Research Group, Ministry of Supply. Radar pick-ups of bird flocks were made as early as 1941, and similar occurrences have been reported from other countries, including the United States; but it is only now that wartime restrictions on publication of the information have been lifted.

Longest radar track on a flock of geese thus far recorded was one made by a station of the R.A.F. on the coast of East Anglia. The birds were kept in the radar field for 99 minutes, during which time they flew 57 miles—an average of 35 miles an hour. Another station picked up the same flock and tracked them for an additional 22 miles, at a ground speed of 33 miles an hour. The geese were never seen, but when they crossed the coast near a Royal Observer Corps post they were identified by their call as gray geese.

Gulls as well as geese have been picked up by radar, and even small birds travelling in flocks. Experimental proof that birds actually do produce radar echoes was produced by suspending a dead gull beneath a balloon and "radaring" this known target. The echo from the bird's body could be clearly distinguished from that produced by the balloon.

When approaching flocks of birds were first detected by radar it created some confusion, but this did not last long because of the great difference in speed between even the fastest of birds and the slowest of airplanes. Birds continued to create some disturbance, however, because their speed is close to that of fast surface craft. During the war, birds gave rise to several E-boat scares and to at least one invasion alarm.

THE ROLE OF AIR TRANSPORTATION IN THE FUTURE*

BRIG. GENERAL M. W. ARNOLD
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This occasion is a great pleasure to me for several reasons—first, as a member of the armed forces to have the privilege of giving you the background on the progress of air transportation during the past few years, particularly during World War II, and secondly on account of my personal pride in the teaching accomplishments of the armed forces. Approximately 80% of our job during peacetime is devoted to teaching. I have no illusions about my ability as a teacher, but the fact that I have been asked to talk to so distinguished a group of people representing the profession of teaching is very gratifying to me as a member of the armed forces.

I recall quite vividly an experience which befell me quite a few years ago. I obtained a job as counselor in a boys' summer camp in an intermediate division prior to taking my flying training. During the day I had duties of instructing several classes of boys and at night I was quartered with eight members of the camp ranging in ages between eleven and fourteen. Not only were they eager to learn and interested in all problems, but they were also able to serve as realistic critics of anything and everything which was presented to them. As an example, it was my duty to tell a story each night, and I assure you the story had to be good, or else they were quite outspoken in their disapproval.

In my opinion, the recognition of the tremendous work performed by the teaching profession in America can only be evaluated properly by the personal satisfaction of those who have engaged in this most important work in the life of our nation. If the teaching and the principles expounded by the majority of those responsible are sound in regard to the association of mankind and the association of nations along the lines of principles of democracy, that nation must and will exist as a great nation, regardless of its size. We, as a nation, have a great heritage and great principles, in all of which we individually and collectively, have great pride. Fortunately, or unfortunately, we cannot rest upon our laurels, nor be satisfied with our past

* Presented at the Geography Section of the Central Association of Science and Mathematics Teachers, November 23, 1945.

accomplishments, but must forever look to the future and prepare and plan wisely in order to safeguard the principles for which so many have given their lives. Nor do I mean to infer that only those lives given on the battlefield are responsible for the continuation of our principles of democratic government.

The position of air transportation in the future plans for America will play a great part in maintaining our position as a great democratic nation. It will also play a great part in safeguarding our principles. Before going into the position of air transportation in the years to come, I think it is best that we review some of the developments and the progress made by air transportation during the past few years.

Prior to 1938 the combined interests of all airlines in America could have been purchased for ten million dollars. The first piece of freight carried by air was a shipment of five bolts of silk carried on the knees of the pilot of a Wright bi-plane from Dayton to Columbus, November 7, 1910. On December 7, 1941 air transport in America represented a total of 359 airplanes which the combined airlines of America operated.

In May 1941 the Ferrying Command was created. The sole assets of this Command consisted of two officers, four enlisted men, a map of the world and a job to perform. That Command, renamed "The Air Transport Command" May 29, 1942, was designated by Executive Order of the late President Roosevelt as the official air transportation agency not only of the War Department, but of the United States Government. Not only did we enter World War II without transport aircraft and trained personnel, but we also entered it without communications and weather service and, above all things, without maps—all of which had to be created and knit into an efficient working organization. The accomplishment of the Air Transport Command has been tremendous, but I think it best to say the accomplishment of America has been great, as we in the armed forces feel that the Army is a true cross section of American life.

The organization of air transportation as of V-J Day was a far cry from the exploratory flights and the first operations commenced in 1942. I vividly recall the difficulties encountered in the institution of the North Atlantic ferrying route for the delivery of the first bombers and fighters to Europe. The accomplishments can be termed as most outstanding and most unusual and all the other superlatives, but the task was in reality not a difficult one in view of the fact that never in the minds

of any of us did we doubt the ability of America to do the job, nor did we doubt the necessity for doing the job, since every American was imbued with the knowledge that our cause was right and necessary for the existence of our democratic principles of life.

At the cessation of hostilities, Air Transport Command routes stretched more than 166,000 miles, or more than six times around the world. These routes were vastly more than the thin vein-like lines portrayed on aeronautical charts. Actually, they were throbbing arteries through which tremendous power was pumped to the sinews of the Allies. The Command's aircraft flew more than two million miles every twenty-four hours—most of the mileage compiled on overseas flights or over foreign lands. Roughly, 25% of the flying entailed the ferrying of military aircraft; 75% was in transport service. It ferried abroad slightly over 50,000 combat aircraft, both bombers and fighters.

It flew more than 580,000 tons of high priority cargo abroad in 1944, including in the neighborhood of 3½ billion pieces of troop mail. Its monthly lift prior to V-J Day was over 100,000 tons.

Air Transport Command planes crossed the Atlantic once every 19 minutes, the Pacific once every 51 minutes in normal operations. Redeployment operations made it necessary for the transports to bridge the Atlantic on the average of once every 6 minutes.

No single item can be accurately described as typical air freight carried by ATC. Illustrative of the great variety of cargo that moved by air were missions which involved the delivery of:

55,000 lbs. of incendiary bomb fuses and 8,000 pounds of electrically-heated flying gloves and boots to the 8th Air Force in England.

Several tons of fuses used by General Clark's ground forces to knock out strongly fortified pillboxes during the siege of Cassino.

50,000 lbs. of aircraft replacement parts to a Navy carrier force awaiting departure at Pearl Harbor, and 10,000 lbs. of engine parts urgently needed by another Navy task force standing by in the Southwest Pacific.

55,000 lbs. of mine-cutting equipment to the Navy in England on the eve of the invasion, and hundreds of rolls of luminous tape for Allied paratroopers' helmet markers.

1,500 lbs. of special valves for a Texas petroleum plant faced with shutdown in the production of aviation gasoline.

1,500 pints of whole blood a day to the European Theater prior to V-E Day. From January through mid-May 1945, some 475,000 lbs. of whole blood were flown to Europe.

A decisive engagement in the conquest of Okinawa came at Shuri Ridge, where the Japs staged their supreme defense of the

city of Naha and the southern portion of the island. The 10th Army ran into a temporary stone wall and the most fanatical sort of resistance. Then the 10th ran perilously short of mortar shells at a time when mortar fire was one of the most effective methods of infantry support. In a matter of hours, ATC flew some 36,000 rounds of 81 mm. mortar shells into Okinawa.

The Air Transport Command operated 3,707 aircraft at the height of its operations and landed these aircraft at 336 different points in foreign lands prior to V-J Day.

A total of 125,370 military personnel—the equal of more than eight Army Divisions of 15,000 men each—was returned to the United States by air from the European and Mediterranean Theaters from May 1 through July 1945.

From January through May 1945, 39,486 ambulatory and litter patients were flown to the United States by ATC—considerably more than the 32,000 transported in the full year of 1944.

During the first four months of 1945, the ATC carried 684,528 war-important passengers, including 596,993 to and from foreign points—equivalent to a yearly rate of 2,053,584 passengers, representing a 64% increase over the 1944 passenger rate of 1,250,000. Those passengers were flown 1,368,198,180 passenger miles during the four months. That feat is equivalent to moving the population of Omaha, Nebraska, from San Francisco to Guadalcanal.

The accident rate of the Air Transport Command for 1944, which included foreign operation of transports and foreign ferrying, was .41 per thousand hours' flying. The accident rate for the 7-month period of 1945 was .26 per thousand hours of flying. For your information, since the cessation of hostilities, the accident rate for September for ATC was .17 and the October rate was .12—an all-time low in the history of the Command. Of the 19,000 patients flown in the first quarter of 1945 all were handled without a fatal accident.

In March 1945 the Air Transport Command employed 159,000 military personnel and 90,000 civilians.

For your information and future reference, I have compiled a few pertinent facts on a separate sheet which will be made available to you, along with a print of the routes flown by the Air Transport Command.

You may correctly and properly ask the question, what bearing does the development of air transportation during a war

have on our national security or upon our economic position as a nation in the future years of peace. I believe this is a proper question as there is no question that America did a stupendous job and air transportation did its part, but what effect does the job performed during the war have on our future? Personally, I think that it will have a tremendous effect and that we have seen only the beginning of the development of air transportation. The exploitation of the airplane in its various phases as we know it today and as we will know it in the future has eliminated the geographic boundaries which we Americans considered as of primary importance prior to World War II. It has been suggested that in the geography books of the future we present, along with our studies of land and sea, a new page—that page should be entitled "The Atmosphere of the World." It has no barriers and as such, for purposes of discussion, we could consider it as a boundless area. The coloring and shading would be of no importance. Unquestionably, it is the sincere desire of every true American to eliminate wars forever. That is the big problem that confronts each of us, but certainly you as teachers have a greater part to play and have greater influence in determining the policy of America than any other profession.

The day of jet-propelled aircraft, rockets and guided missiles is no longer a dream of Jules Verne and Flash Gordon. Possibly, you may ask what nation or what group of nations will fight America or wage a war of aggression in the future. Honestly, I do not believe that any human being can answer that question today. We only know and can only prove through the experience of the world, which is generally labelled "history," that nations do wage wars and groups of people are placed in power who have no regard for the principles and rights of others. Until such time as this axiom has been disproved and man has progressed and the world, through experience, can say that no war is possible or practical, we have certain obligations to the future generations of America to insure that no groups will attempt again to force the will of aggression upon others. America has a great future; a great era is just over the horizon for the next few years. New developments in plastics, electronics, medical science and air transportation will greatly enhance the enjoyment of life and the pursuit of good living in America. I do not attempt to predict here how long these years will last, but what we are planning and what we are developing in the next few years will more than likely determine the trend of events

twenty-five or fifty years from today. It is very well for us to say "Let tomorrow take care of itself"; tomorrow will take care of itself if today we properly perform our duties and lay our plans for tomorrow, based upon the practical application of our actions toward the future. Air transportation and the maintenance of freedom of the skies is the greatest insurance that our children and our grandchildren will not blame us for failing to properly foresee the turn of events in the future. The blank page which I referred to as the "Atmosphere of the World" is America's first line of defense.

What equipment is presently available for the future development of air transportation? The transport version of the B-29, known as the C-97, is now in production. This aircraft will carry 134 passengers at a speed of 289 mph. The C-69, known generally as the Lockheed Constellation, also is in production and has been purchased by several of the airlines. This airplane has a seating capacity of 60 and cruises at a speed of 276 mph. Tremendous developments in aviation have been witnessed, such as jet propulsion and rocket assists. It is not impractical to foresee very shortly huge transports taking off assisted by rocket propulsion, combination transports with conventional type engines, shifting to jet propulsion at high altitudes utilizing pressure cabins. In the next five to ten years it is my belief that we will see generally the conventional type aircraft in much greater numbers with greater seating capacity, improvements in the control of air traffic through developments and perfection in the field of television and radar, blind landing devices using very high radio frequencies, radar and electronics. Unquestionably, the number of weather cancellations on commercial airlines will decrease as these safety devices are perfected.

America has led the world in the development of aviation since the first flight made by the Wright Brothers. Our position and directions were clear-cut during World War II in the utilization of air power and air transportation.

A world wide air transportation operated by free competitors is the practical application of the Fifth Freedom as outlined by the Chicago International Civil Aviation Conference held in September 1944. The free operation of American air transportation throughout the world will bring closer together the nations in the coming years of peace and will tend to eliminate the distrust and jealousies which so easily develop behind barriers and artificial prohibitive regulations.

Let us turn back the pages of history and examine a few of the facts which may or may not be too pleasing, but, regardless, do exist. We as citizens are all very proud of our citizenship, but in order to reap its benefits and to properly take pride in our greatness we have obligations as individuals and as a nation. We are on occasions prone to criticize the methods and principles employed by others; yet we have refused to accept the obligation of correcting those so-called improper actions on the part of individuals and nations. Let us not make that mistake again. We have obligations to the men who have given their lives in this war and all other wars, as well as the obligations we automatically assume for the coming generations. All those things we inherit with our American citizenship. The existence of America is much greater than local prejudices and disagreements. If we, along with the future generations of America, can properly determine the right obligations and the right road to take, America should never be involved in another conflict. Such an idealistic situation may possibly not be attained regardless of our efforts, but we can at least have this as our goal in the same manner as we of the armed forces feel that fatal aircraft accidents will occur as long as man errs in his judgment and materials fail; but, regardless of this fact, we attempt to eliminate all accidents and have as our goal a perfect record.

There is no question of the patriotism of the American youth; his actions and sacrifices during the past war were by far the most stirring and gratifying that I have observed. His display of devotion to the principles and ideals of democracy is a matter of record and needs no more exposition from me, but there is a question in the minds of a great number of people whether such devotion and such sacrifices will be sufficient in the event of another war in the future. It is not too theoretical or too hypothetical to assume that no nation will exist as such if the world is embroiled in conflict again.

Today America is facing the most critical era of its existence. There were a few differences of opinion on this country's position during World War II, but generally our direction as a nation was clear-cut. There were variations in the procedures and there may be possible ways of proving that we could have accomplished our great victory in some instances through more efficient methods. But such a discussion is immaterial in comparison with the many important questions which confront us as a nation today. One of the most important is the maintenance of a

determined national policy in the international field of commercial and military aviation. It is far better to prevent disease, prevent accidents and prevent wars than to cure the ills through a major operation. We have proved this fact as a nation—and all the other nations of the world have proved it—too many times to attempt to add another case to the history.

In examining the period between World War I and World War II, some rather interesting facts present themselves. A democratic type of government existed in Germany from July 1919 until the national socialist revolution in 1933. Unquestionably, there were many faults in the Weimar Republic, but at least it was a step in the right direction. Heinrich Bruning, the Chancellor of the Weimar Republic from 1930 to 1932, made an official journey to Paris in 1931 to call upon Pierre Laval, then Minister of Foreign Affairs for France. The results of that conference had tremendous effects upon the events of the world in the years to come. Bruning pleaded and begged for a loan to support the current government of Germany. Pierre Laval refused to present the request to the French Cabinet and extended no hope to Heinrich Bruning, although Bruning had warned him of the chaotic economic conditions which would engulf Germany if the loan was refused. He also spoke of the sinister forces which unquestionably would take over Germany if the existing government failed. Ladies and gentlemen, I do not have to refresh your memories any further, as you are probably more familiar with the details of what happened in the economic and political era from 1932 to 1939 than I. Numerous well-known Americans warned this country of the developments taking place in Germany in 1936 and 1937. We as a nation verbally stoned those prophets and took no heed of their advice. Those are the obligations I spoke of which we have as a nation. Those obligations extend to the world the same as the atmosphere extends to all nations. By insuring a sound peacetime air transportation and freedom of the skies, we can insure the freedom of America in the years to come.

PAY FOR TEACHERS

The people who should will not go into teaching unless it is more respected and more highly paid as *teaching*, not as superintending or administering.—From *General Education in a Free Society* (Harvard University Committee).

NEW DRUG DEVELOPMENT*

EDWARD J. MATSON
The Abbott Laboratories, North Chicago, Illinois

Your chairman has asked that I give you some idea of what goes on in the mind of a pharmaceutical research chemist, and why. Neither the "what" nor the "why" is simple to answer, so that I shall probably have to do so by an indirect route. Perhaps if I can describe for you the fetal development and the birth of a new synthetic drug, you may see what lines the chemist's thinking follows.

First, though, I should tell you something about the organic chemist. Particularly in the field of drug research it has become necessary for the chemist to have as thorough training as possible, and so you will find that almost all chemists in this field have the Ph.D. degree. This has become more and more a "union card" that is necessary for getting a job in drug research. The reason is that the field is so broad and so continually requires familiarity with almost every phase of organic chemistry. Because there is very little that is systematic about the relationship of chemical structure of compounds to their physiological action, there has never been a successfully systematic book written on the chemistry of drugs. This means that the chemist must be able to develop out of his thorough training in organic chemistry and his increasing familiarity with the nature of drugs an insight into the problems that arise constantly before him.

The organic chemist realizes that, in the study of drug action, his science is only one leg of a tripod, as Loevenhart has said. The other two legs are pharmacology and clinical medicine. The chemist would be helpless indeed if he did not have the pharmacologist to study the action of his compounds on experimental animals, and both would be helpless if the research clinician were not available to carry carefully these suggestive observations into the field of human therapy.

In a relatively new field the organic research chemist is more than happy if one compound out of a hundred has sufficiently interesting properties to warrant detailed pharmacological study, or if one in five hundred ever reaches the stage of critical clinical trial. Even before this stage of development, other

* Presented at the Chemistry Section of the Central Association of Science and Mathematics Teachers, November 23, 1945.

groups must be brought into the picture. It is the task of the research pharmacist to develop a stable, attractive, palatable form for administration. The form may be either a tablet, a capsule, a granule, a syrup, an elixir, powder, an effervescent combination, an ampoule of a solution, a lozenge, an ointment, a suppository, an inhaler or any one of a number of other forms, depending upon the characteristics of the substance and its intended use. A tablet may be coated or uncoated; certain enteric coatings based upon research developments in the field of synthetic resins now permit a prolonged stay of the tablets in the stomach without disintegration, but rapid breaking up in the alkaline intestine.

The research pharmacist must ascertain how the finished pharmaceutical will withstand freezing if sent to our forces in Alaska, or on the other hand how it will be affected by the heat, light and humidity of North Africa or the Solomons. Samples held in special rooms where these conditions are maintained must go back to the chemist and the pharmacologist for frequent check of potency.

Chemical reactions frequently are more temperamental and need more careful coddling than any infant. The method of synthesis used in the research laboratory was probably chosen as a matter of convenience without regard to chemical expense. In production the most economical route must be devised, which may well involve entirely different reactions and consume many more months of intense effort. As a prominent industrialist once said, "Make your mistakes on a small scale and your profits on a large one." It is usually impossible to go directly from a laboratory scale to plant production. This necessitates the establishment of a "development laboratory," or what we call a "pilot plant." Each piece of equipment is a miniature of that to be used in the final plant in order to rule out as far as possible such variations as rate of stirring, rate of heat transfer and contact with metal surfaces. Frequently, reactions which proceed nicely in Pyrex glass in the laboratory fail completely under these new conditions, the presence of metals or the longer reaction times inducing decomposition. Final transfer to plant production raises anew a similar set of unpredictable variables. The anxious father in the obstetrics ward waiting room has no more nerve wracking session than the plant chemist running a dangerous reaction for the first time.

Then, under the Food and Drug Act of 1906 and the Food,

Drug and Cosmetic Act of 1938, the parentage as well as the character of the new drug must be established beyond doubt. Its "fingerprints," in the form of accurate assay methods, are demanded. Toxicities and possible dangers must be well established as well as its therapeutic usefulness. Only then is a Federal permit given for marketing in interstate commerce.

I should like to illustrate the development of a new drug by telling how some of them have been born at the laboratories where I am employed. Please understand, first of all, that the illustrations could just as well be drugs developed in other pharmaceutical houses, but it so happens that I am best acquainted with the research carried on at Abbott Laboratories.

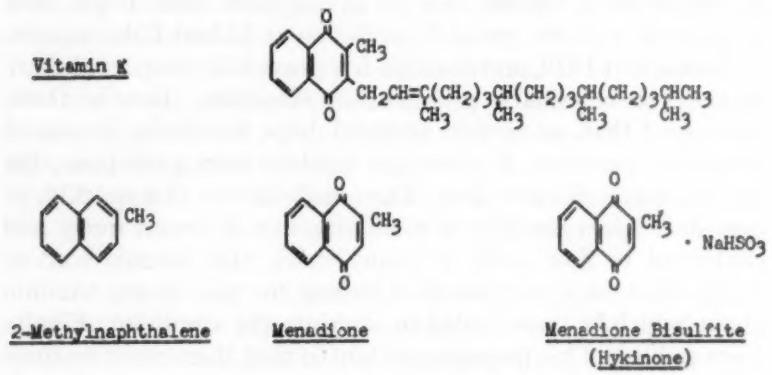
Back about 1929, and during a few years following, an obscure student of veterinary problems in Denmark, Henrik Dam, discovered that, on certain artificial diets, his chicks developed a strange condition. If a few pin feathers were pulled out, the wounds made did not close. The blood did not clot quickly, as ours does when we have a small cut, but it flowed freely and continued to flow until, in many cases, the animals bled to death. Dam was very much mystified by this. Every vitamin about which he knew failed to improve the condition. Finally Dam published his findings and hinted that there must be some unknown factor missing from the diet of the chicks.

The head of our nutrition research department, a Dane by birth who always has kept one eye cocked toward the scientific research in Denmark, noted the paper by Dam, and wrote him to express interest in this unknown food factor, indicating his belief that this discovery in chicks might someday be related to some of the many causes of hemorrhage in humans. A correspondence followed which was most informative to us. We learned that chicks having the hemorrhagic disease recovered quickly when they were fed cabbage or alfalfa or even decomposed fish meal, and based on these hints our research began.

It was first apparent that some low-cost material such as alfalfa would be the most feasible raw material. Then, after some study, our chemists found that they could extract the active principle from alfalfa with a low-boiling gasoline. Many months of research passed, with operations taking place on a larger and larger scale, until finally we were able to produce in our plant a concentrate of the antihemorrhagic factor, which was called vitamin K by that time, from hundreds of pounds of alfalfa all at once.

Just at that time the prediction of our director of nutrition research came true, when medical research experts announced that they had discovered that vitamin K was important to human health.

For many years surgeons had dreaded having to operate upon patients having the condition known as obstructive jaundice, because for some unknown reason their blood would not clot and there was great danger that the patient would bleed to death. And now the cause was discovered. Patients with obstructive jaundice do not secrete bile normally into the intestine,



and we require bile salts in the intestine in order to aid the absorption of fats and fat-soluble materials into the blood stream. Vitamin K is a fat-soluble compound, and in obstructive jaundice it is not absorbed from the food. It was found that vitamin K is essential for the production of prothrombin, a necessary part of our blood-clotting mechanism. And so patients with obstructive jaundice tended to hemorrhage after an operation.

Furthermore, it was found that vitamin K was lacking in some newborn infants who died of hemorrhage because their blood lacked prothrombin. Vitamin K administered at once, or to the mother before the birth of the child, quickly restored the baby's blood to normal.

When these facts were published, there were universal demands for this magical new vitamin, and because Abbott had carried its research along for many months it was ready at once to supply the great demand.

The situation was quiet then for a year or two until Doisy and his group at Saint Louis University one day announced that

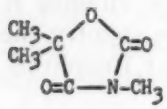
they had determined the structure of vitamin K. As you can see, it is complicated, with the long phytyl group as a part of it. Chemists began to scurry around for the best ways to synthesize it, and were hard at work when word came that the whole vitamin molecule was unnecessary, that only the simple nucleus, 2-methyl-1,4-naphthoquinone, or menadione, was required to stimulate the production of prothrombin in the body. Research on the economical production of vitamin K came to a standstill as in every drug house in the country the question arose, "How do we make 2-methyl-1,4-naphthoquinone?"

The answer was soon apparent that it must be made by the chromic acid oxidation of 2-methylnaphthalene. And as chemists studied their catalogs a new star rose in brilliance as rapidly as a nova. For a long time the Reilly Tar and Chemical Co. in Indianapolis had told chemists that it knew how to isolate pure 2-methylnaphthalene from coal tar. Little attention was paid to this announcement until the news about menadione was released. Then from all parts of the country telegrams were rushed to Reilly, "Send us some 2-methylnaphthalene." Fortunately, Reilly was able to supply the demand, and soon chemists were starting down the familiar path from laboratory to pilot plant to full-size plant production.

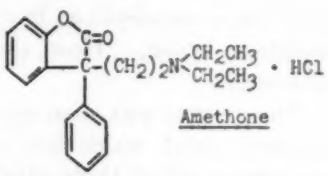
Again things were quiet for awhile, until doctors complained that menadione was a drug which must be given orally and must be administered to jaundiced patients along with bile salts. What was really needed in many cases was an injectable form of menadione.

Since menadione is almost insoluble in water, it was apparent that another approach would have to be made. And so the long search began again. At Abbott a satisfactory solution was finally arrived at when it was discovered that menadione would dissolve in a dilute solution of sodium bisulfite. With a sigh of relief Abbott chemists turned from the fundamental question to the many problems involved in making a solution which could be sterilized without decomposition, would be stable, readily injected and so on. Finally the problems were all solved, and in menadione bisulfite, or Hykinone, they came to the end of the long road which began when Dam (who with Doisy received the Nobel Prize last year for their successful research on vitamin K) noted that his chicks were having hemorrhages when their feathers were pulled out.

I should like to mention briefly the recent development of another new drug. This is of interest because, as so frequently is the case, its usefulness was discovered by accident. Not long ago there was developed in our laboratory a new drug called Tridione, which was produced as an analgesic, that is, as a "pain-killer." And in several applications it was pretty good, good enough to merit extensive study in the relief of human



Tridione



Amethone

pain. At about the same time we began to study a series of compounds which we hoped would be effective in counteracting spasms of the involuntary muscles. The one which was finally selected was Amethone, which does a very good job in controlling spasms of the genitourinary tract and perhaps of the intestinal tract and the biliary tract. Then it occurred to our chemists that the analgesic action of Tridione and the antispasmodic action of Amethone might logically be combined for the treatment of dysmenorrhea.

Now, when a lethal dose of Amethone alone is given to an experimental animal it dies in convulsion. And yet when enough of the Tridione and Amethone mixture was given to an animal so that the pharmacologist expected the dose of Amethone to be fatal, no convulsion at all was observed.

To an alert pharmacologist this meant that Tridione possessed an entirely unpredictable anticonvulsant effect, and further study proved it to be true indeed. For as the drug was turned over to medical specialists for trial, it was found that Tridione was effective against a form of epilepsy for which no satisfactory drug had previously been known. In *petit mal* epilepsy children, and less often adults, have a brief loss of consciousness. In other types there may be brief periods of convulsion. These types of epilepsy differ in intensity from the "fit" of *grand mal* epilepsy, but also differ in that attacks may come dozens or even hundreds of times a day, which of course completely incapacitates the victim for any kind of useful effort. Encouraging evidence has accumulated during the past year that Tridione is successful in a great majority of these

cases, enabling afflicted persons to return to society, attending school and even engaging in steady employment. Thus through serious chemical research combined with attentive animal experimentation a new valuable drug holds promise for the future.

MARKING ON A CURVE

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Every teacher recognizes the importance of proper and meaningful marking. The final grade is supposed to give an indication of the degree of mastery which the student attained in the subject. In order to be meaningful the measure of achievement must be based on some widely used standard; otherwise an evaluation of the educational background of an individual on the basis of his school grades would hardly be possible. It is conceivable that in one and the same school one teacher would give a student a high mark, while another would consider the same student's achievement only as barely satisfactory. Both teachers may have a reason for their action; the former might have based his mark on the student's relative standing in the class, while the latter tried to give a grade which would have an absolute meaning.

There can be no doubt that a great deal of this ambiguity in the meaning of grades is due to the widespread use of the so-called marking on a curve. This procedure is supposed to be based on statistical theory and is therefore regarded by its adherents as a process having behind it the powerful backing of mathematics. It appears that a significant number of mathematics and science teachers believe in the soundness of that particular method of marking. They act as if they would not realize that mathematics and science are fields where some universal standards must be maintained if students admitted to higher courses are to be benefited by them. College teachers know only too well how little they can expect from students who completed some two years or more of high school mathematics with fairly good grades. As a matter of fact, the students themselves are bewildered when they find out how deep their mathematical ignorance is, and they begin to wonder why they were given good grades in high school.

It is believed that a clarification of the marking procedures will, among other factors, contribute toward a better organization of the teaching of mathematics in our primary and secondary schools. The purpose of this paper is to critically examine the method of marking on a curve, and to suggest some modifications in the scale of grades for mathematics and science courses.

As the author understands it, the marking on a curve consists in assigning to each class grades in such a way that their percentage distribution will correspond to the percentages of the area under the normal probability curve between specified limits. If, for example, the limits are $(-\infty$ to $-1.75\sigma)$, $(-1.75\sigma$ to $-\sigma)$, $(-\sigma$ to $\sigma)$, $(\sigma$ to $1.75\sigma)$, and $(1.75\sigma$ to $+\infty)$, the corresponding percentages would be approximately 4, 12, 68, 12, and 4. In practical situations the setting of the limits may depend upon the percentage of students whom the teacher decides to fail. The percentage for the central grade may be kept constant at 68 while the percentages for the other grades will depend upon the anticipated number of failures. This procedure is exceedingly simple to apply since all the teacher has to do is to arrange a class list by rank, and then to compute the number of students "eligible" for each grade.

The method of marking on a curve is based on the implicit assumption that for each classroom the distribution of student scores on tests does not differ significantly from a normal distribution. However, such is generally not the case. It is possible that if a scientifically prepared test were given to a large, nonselected number of students, all of whom were taught under essentially the same conditions, the scores would approximate a normal distribution. But, a normal distribution of marks on a test in a single classroom would be a rare accident indeed.

There are several factors which would generally contribute toward a skewed distribution of marks in a classroom. First of all, it is not certain whether absolute scores would follow a normal distribution altogether since there are numerous human characteristics which show a more or less strongly skewed distribution. A distribution of scores or grades based on information furnished by many schools will not provide conclusive evidence one way or the other, since the equality or even similarity of conditions other than the students' personal characteristics is seriously open to question. Furthermore, a

distribution of grades in a large school or school system may be completely artificial, especially if a majority of teachers adheres to the practice of marking on a curve. The second factor to consider is the applicability of the tests used. It is obvious that a test which is too easy or too hard will produce scores clustered in the neighborhood of the very high or very low figures, as the case may be.

A third reason why normal distributions are not likely to occur in a classroom is because the pupils frequently belong to a select group. In certain large cities it is conceivable to have schools with pupils generally brighter than the average and some other schools with pupils for whom the reverse is true. If a standard test were given in such schools, the scores cannot be expected to follow even approximately a normal distribution. Any teacher familiar with the methods of computing a mean and a standard deviation may easily convince himself that the normal probability curve will generally not be applicable to the distribution of scores in any of his classes. If this be granted, the scientific aureole surrounding the marking on a curve fades away immediately.

The simplicity of marking on a curve is not of sufficient importance to counterbalance the lack of scientific justification. Neither is the satisfaction of students with this method a factor of sufficient weight. This marking system provides no incentive for the brighter student who happens to be in a class with many poorer ones. His high grade is bound to come to him by default with a minimum of effort. On the other hand, in a very poor class, some below-average student may receive the highest grade simply because there was nobody brighter than he. The next semester the same individual may land up in a class with better students and find himself near to the bottom, again because of the peculiar workings of the marking on a curve.

The following suggestions are offered as a possible modification of the marking system for subjects in which higher courses cannot be taught successfully unless the students acquired a sufficient mastery of the prerequisites:

1. Final grades should be based upon standard tests. In large school systems these tests should be the same for all schools.

2. The method of marking on a curve is to be abolished. Teachers should be made to understand that no attention will be paid to the distribution of grades in their classes.

3. A failing mark should be given only to students who did not make sufficient progress and who may be expected to profit by repeating the course.

4. Students who lack the background for the course in which they are about to fail should be given a special mark which would give them credit for the semester but would not permit them to enroll in a higher course.

Such a reform in the marking system in the high schools would achieve the following objectives:

1. Grades will be absolute, not relative.

2. The number of formal failures will be kept at a low level.

3. The student's inability to catch up with a subject will not be augmented each semester by virtue of permitting him to enroll in more difficult courses.

4. The student adjudged incapable of mastering the course will not be penalized with respect to graduation credits, but will be stopped from getting into greater difficulties. He will be able to acquire sufficient background by attending some special preparatory course.

5. While a student will be able to graduate without having actual credits in the required subjects, no harm will be done since his record will show in what subjects he is completely deficient.

EARTH SCIENCES IN 1945

Complete world weather information was made available for forecasting when exchanges of meteorological data with Japan and Russia were developed.

There were 43 earthquakes of sufficient strength to record themselves on distant seismograph instruments; a quake-caused tidal wave in November killed 4,000 people on the northwest coast of India.

Radar can be used, it was announced, in detecting approaching storms up to 200 miles away.

A new yellowish-green gem stone was described, and given the name of Brazilianite for the country of its origin.

Constant pressure upper air charts replaced constant level charts as official Weather Bureau maps as a basis for domestic aero weather forecasts.

Maps showing trafficability of enemy country, sources of construction material, areas where underground water supplies could be obtained, and other geological features, aided Allied invasions.

INTENSIVE INDUSTRIAL TRAINING*

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If we were to trace the history of civilization from its earliest beginnings down to the present, we would undoubtedly find that industrial training, in some crude form, may have preceded that kind of learning which could properly be called education. The two terms are not quite synonymous. Education is described by one of the dictionaries as, "Moral and mental discipline gained by study and instruction," while training is defined as, "The practice of something to gain skill or ease." Hence, when Joe Stonehatchet first taught his prehistoric sons how to fashion weapons and tools of stone, he was training rather than educating them. Education, as we think of it today, probably began when some early thinker first recognized the existence of certain phenomena governing the universe in which he lived and sought to discover and interpret them for the welfare of his fellows.

The basic differences between education and training must be clearly understood and not forgotten when we discuss industrial training. Educators are inclined to think in terms of education, while the industrial man is vitally concerned with training in specific skills. It is because of this divergence in viewpoints that the thoroughly practical industrial executive sometimes charges that the professional educator looks upon education as an end in itself, rather than as a preparation for life or a career. Within the scope of his industrial field, he thinks in terms of jobs to be done and competent people to fill them. He wants trained men and women. When he cannot recruit personnel with the training needed for the jobs he has to offer, he will seek the means to train them quickly, thoroughly, or as the subject of this paper indicates, intensively. Usually, the industrialist finds that he must do that training within his own organization. He probably would much prefer to have experienced educators do the job for him in schools and colleges, but he has found that more or less impractical if not impossible in average situations.

Because industry employs men and women in such an endless

* Presented before the Junior College Division, Central Association of Science and Mathematics Teachers, November 24, 1945.

variety of occupations, the industrial training job is never a simple one. For that matter, a system of training which will suffice for one type of industry may be utterly inadequate for another. The techniques employed are many, some relatively new, and quite a few very old.

The old English Guilds, which operated successfully for many, many years before the Black Death helped to disrupt them, provided training for the artisans of the time. The Master Craftsman and the Journeyman taught their skills to the Apprentices who were bound to them in the Guild system. That method of training, in revised form, survives to this day in many skilled trades.

With the advance of modern civilization and the coming of the industrial revolution, there came a rapidly increasing demand for unskilled workers. It was not considered necessary that the average worker in the factory should have much education. Employers depended upon experience to teach the laborer whatever skills he required. Even today there are many jobs in the average industrial plant which do not require any great mental development and in which an educated person would be quite unhappy and, as a result, unsatisfactory to his employer. However, as industry becomes more and more technological, the common labor types of occupations decrease and there becomes an ever greater demand for men and women with varying degrees of education, plus specific training.

In the years immediately preceding the second world war, this nation was emerging, somewhat feebly, from the pit of history's greatest business depression. For some twelve years previous, industry had been a crippled, halting thing. The industrial worker had struggled through a time when it did him little good to have either education or specific industrial training and experience. Some of our large corporations had no employees with less than fifteen years of service remaining at work in 1932. If an employer wished to hire a skilled toolmaker in those days, all he had to do was to open the employment department door and pick one out of the waiting job hunters.

Is it any wonder, then, that there was precious little done in the field of industrial training during those years? With such an over-supply of experienced workers available, young men were hesitant about studying for technical careers. This combination of circumstances resulted eventually in a tremendous and critical shortage of trained personnel to man the huge factories

which sprang up like mushrooms after the bombing of Pearl Harbor. The supply of experienced people disappeared almost at once, either swallowed up by hungry employers or taken into the armed forces. Thousands of men and women who had never before seen the interior of a factory were placed in technological positions; before lathes, grinding machines, at drawing boards, and in a host of other positions demanding special and often meticulous training. With such a jury crew manning its factories, America fought and won a highly mechanized war; a war that saw scientific and mechanical achievements almost beyond belief.

In a large sense, this miraculous achievement was made possible only by our system of compulsory education plus a tremendous revival of and improvement in training. Americans had a basis of education upon which to build. Every device for teaching skills quickly and effectively was used. The U. S. Office of Education and other agencies concerned with industrial training were given millions to spend upon training programs. You are familiar with what they did, I am sure, so I shall not attempt to enumerate them. At Illinois Institute of Technology alone, more than fifty-five thousand men and women completed short, intensive courses in war-necessary subjects on the college level. The national total, including all levels, is undoubtedly so astronomical in size that it would be hard to comprehend.

It is of course impossible to draw a sharp line between education and industrial training. The programs offered so successfully during the war by educational institutions and within the war plants were largely a combination of the two. Industrial workers received training in specific jobs it is true but it was necessary to give them a certain amount of basic education in mathematics and certain of the sciences. We trained many technicians, for example, who had to learn much which was of an educational nature before we could superimpose upon that knowledge the practical training for the specific occupations in which they were placed. In order to accomplish that end, cooperation between educational institutions and industrial training men was imperative. We found it most effective therefore to bring into our war training programs practical industrial men who could help us to coordinate the purely educational aspects of the training programs with the more specific requirements established by the individual occupations for which the training was designed. In this way we were able to prepare a great many

men and women for technical positions in a remarkably short time.

A great many of the large corporations were able, during the war, to set up and operate successfully comprehensive training programs within their own organizations. Some of those programs will be perpetuated in the post war era. Perhaps some of of them will fall by the wayside.

We must remember too that American industry consists mainly of a great number of small organizations. Census figures indicate that considerably more than ninety percent of the nation's industrial concerns employ fewer than two hundred and fifty persons each. Obviously such small concerns cannot afford to maintain their own training departments. During the war we found that our classes were composed of a great many employees from plants of that size but that there might be only one or two persons in a particular class who came from the same company. It is altogether likely, therefore, that the war training programs were of greater value to the small concerns than to those corporations who, because of their size, could do the job themselves.

Now that the government is no longer sponsoring education and training for industrial employees other than returned veterans, the average industrial organization is left to its own devices. Because of the benefits which they obtained from the war training programs it is quite certain that those concerns would welcome an opportunity to cooperate with any reliable educational organization which could show them a feasible plan of educational and training cooperation. Even before the war American industry had shown a definite interest in such movements as the cooperative plan of education in which the employer and the technical college worked together to provide the means of living and of gaining an education to ambitious young men.

We know that industrial men are ready and anxious for the renewal of the cooperative plan of education for their employees, for many of them have assured us that they will again participate and still others have expressed a desire to enter into such arrangements.

We should also consider, at least briefly, the attitude of labor unions toward education and training. Certain of the old trade unions have sponsored apprenticeship programs for their mem-

bers for many years. More recently they have evidenced a desire for more universal educational programs for the general welfare of their memberships. The CIO, for example, has established an educational and training division for the purpose of operating educational and training programs under its own sponsorship. It is quite likely that the other unions are taking similar steps, if they have not already done so.

Although these various movements may have had independent beginnings they are all pointed in the same direction, toward a common goal. Educational institutions learned a great deal about industrial training during the war. Industrial executives had impressed upon them, as never before, the value of coordinated education and training for production. The labor unions have indicated a similar attitude. Finally the industrial employees themselves have shown, by flocking to war training classes by the thousands, how willing they are to receive such training if it is made available to them. In the light of these favorable conditions the future of industrial training appears bright indeed. Government sponsorship is no longer needed if the educational leaders in the various local communities will step into the role of coordinator.

If I were at the head of an educational institution today I would make certain that there existed within my organization an industrial advisory board or some such committee to keep me in touch with the industrial needs of my community and to foster and encourage cooperation between my faculty and the industrial officials to whom my graduates would eventually go for employment. On that board would be representatives of the faculty, the business and industrial men of the community, and men with the interests of labor at heart.

Under our present systems we can never entirely combine education, as such, and industrial training. It is equally true that the two can never be divorced. As the technology of industry increases the educator and the industrialist must and will be drawn closer together in the interest of the national economy. With the kind of cooperation I have attempted to visualize here the welfare of the community is bound to benefit. The transition from under-graduate to trained employee can be made much more easily by the students we prepare for industrial careers if both educator and employer have cooperated in that preparation.

ELASTICITY OF ELEMENTARY FUNCTIONS

Part 2. Application to Economics

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The study of economics is concerned with such variable quantities as amounts of goods produced and sold, costs, prices, revenues, rates of interest, and other measurable quantities. By making certain assumptions relative to the specific problem and consistent with the nature of the phenomenon under consideration, mathematical functions can be applied to such economic relations as demand functions, revenue functions, cost functions, and others.

Let us suppose that a firm produces a good under certain definite factors of production. If these factors of production are fixed, or assumed to be, then the total cost C of an output of x units is a function of x, say $F(x)$, the form of $F(x)$ depending upon the fixed factors of production, which enter the function as parameters. Unlike the field of mathematics, the variable x in this case has integral values, or at most only rational values. However, in the construction of the cost function $F(x)$ it is reasonable to assume the variable x to be a continuous variable. Moreover, it should be kept in mind that both x and $F(x)$ have only positive values.

The variation of the total cost function $F(x)$ for the entire range of x units of output, that is from $x=0$ to $x=x$, can be expressed in terms of the average cost function $\overline{C}$. That is, $\overline{C}=F(x)/x$.

The variation of the total cost function $F(x)$ for small variations of x is expressed in terms of the marginal cost function C'. That is, $C'=dF(x)/dx$.

The elasticity of the total cost function $F(x)$, by (2), is xdC/Cdx. That is,

$$\kappa=E_x(C)=dF(x)/dx\cdot x/F(x)=C'/\overline{C} \tag{10}$$

where κ is the elasticity of the total cost function. Thus the elasticity of the total cost function is equal to the ratio of the marginal cost function to the average cost function.

Since $\overline{C}=F(x)/x$, by (7), $E_x(\overline{C})=\kappa-1$. That is,

$$\kappa'=\kappa-1 \tag{11}$$

where κ' is the elasticity of the average cost function.

Example 9. Let $C=ae^{bx}$, then $\overline{C}=ae^{bx}/x$, $C'=abe^{bx}$, $\kappa=bx$, and $\kappa'=bx-1$. Let the total cost function be $C=1000e^{.002x}$. Figure 6 shows the average cost curve $\overline{C}=1000e^{.002x}/x$, the marginal cost curve $C'=2e^{.002x}$, the elasticity of the total cost function $\kappa=.002x$, and the elasticity of the average cost function $\kappa'=.002x-1$.

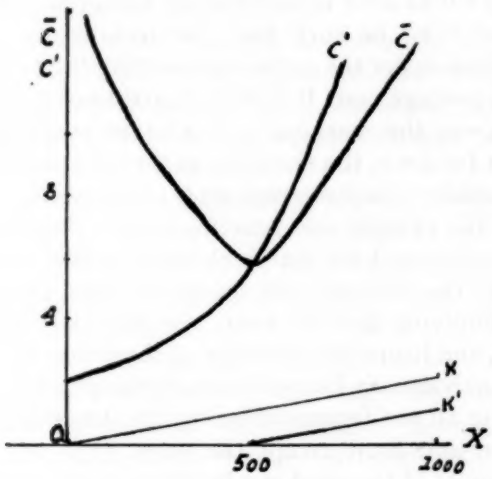

FIG. 6.

For $x=500$, the elasticity of the total cost function κ has the value 1. For this value of x, a small increase in the output x represents an equal proportional increase in the total cost C. By (11), κ', the elasticity of the average cost function, is 0. Thus, for this value of x, the average cost function $\overline{C}$ has a minimum value. By (10), the marginal cost function C' equals the average cost function $\overline{C}$. Thus, $x=500$ represents the case of constant returns.

For x less than 500, κ is less than 1. Here for a small increase in the output x there results a less than proportional increase in the total cost C. The average cost decreases as the output increases. As the average cost is greater than the marginal cost, the values of x less than 500 represent the case of increasing returns.

For x greater than 500, κ is greater than 1. Thus for a small increase in the output x there results a greater than proportional increase in the total cost C. The average cost increases as the output increases. As the marginal cost is greater than the average cost, the values of x greater than 500 represent the case

of decreasing returns. The returns become increasingly unfavorable as the output increases.

The relationship between marginal, average, and total costs can be also interpreted geometrically as follows. Let the marginal cost function be $f'(x)$, then the total cost is given by the definite integral $\int_0^x f'(x)dx$. Thus, the area under the curve $f'(x)$ from $x=0$ to $x=x$ represents the total cost. Let the functional value $f'(x_1)$ be such that the rectangular area $xf'(x_1)$ equals the area under the curve representing the total cost, then $f'(x_1)$ is the average cost. It is to be noted that x_1 varies with x. Since for $x=x_1$ the marginal and average costs are equal, it follows that for $x=x_1$ the elasticity of the total cost, κ, equals 1, and the elasticity of the average cost, κ', equals 0.

Again, if the average cost function is $f(x)$, then the total cost function is $xf(x)$, and the marginal cost function is $f(x)+xf'(x)$. If for $x=x_1$ the average and marginal costs are equal, then $xf'(x)=0$, implying that for $x=x_1$ the elasticity of the average cost is zero, and hence the elasticity of the total cost is 1.

Similar analysis may be used to study the problem of demand. By assuming all the factors affecting the demand for a certain good known and fixed except the price, then the demand in terms of x units of the good can be represented as a function of the price p. Since normally the demand decreases as the price increases, the demand function may be assumed to be a monotonically decreasing function of p, say $x=\phi(p)$. Then by (2) $E_p(x)=pdx/xdp$. In order to make the value of the elasticity of demand positive, we define it

$$\eta=-pdx/xdp. \tag{12}$$

For the demand function $x=\phi(p)$, the total revenue is the product of the number of units x and the price per unit p, say $R=p\phi(p)$. Since the marginal revenue is dR/dx, we may solve the demand function $x=\phi(p)$ for p in terms of x, say $x=\psi(p)$, then the total revenue function becomes $R=x\psi(x)$, and we have for the marginal revenue function

$$dR/dx=p+xdp/dx=p(1+xdp/pdx)$$

which in view of (12) may be expressed in terms of the elasticity of demand as follows:

$$dR/dx=p(1-1/\eta). \tag{13}$$

From the definition of the average revenue, the price per

unit represents the average revenue, that is, the average revenue is p. By (13) the ratio of the marginal revenue to the average revenue is $(1-1/\eta)$.

Now, if for $x=x_1,\eta=1$, then by (13) the marginal revenue is zero, and hence the total revenue has a maximum value. For this value of x a small decrease in price p represents an equal proportional increase in demand x.

For $\eta>1$ at any given value of x, the marginal revenue is positive by (13). This value represents the case of elastic demand, for a small decrease in price represents a greater than proportional increase in demand, and the total revenue increases as the demand increases.

For $\eta<1$ at any given value of x, the marginal revenue is negative by (13). This value represents the case of inelastic demand, for a small decrease in price represents a less than proportional increase in demand, and the total revenue decreases as the demand increases.

Example 10. Let the demand function be $p=a-bx$. Then, the total revenue function is $R=ax-bx^2$, the average revenue function $R/x=a-bx$, the marginal revenue function $dR/dx=a-2bx$, and the elasticity of demand function $\eta=(a-bx)/bx$. For $x=a/2b$, $\eta=1$. Thus, for $x=a/2b$, the marginal revenue is zero, and the total revenue has the maximum value $a^2/4b$.

It was shown in (10) that the elasticity of the total cost function is the ratio of the marginal cost function to the average cost function. The elasticity of the demand function equals the ratio of the average revenue function to the difference between the average revenue and the marginal revenue. For by (13) $(1-1/\eta)=(1/p)dR/dx$, and $\eta=p/(p-dR/dx)$.

SCHOOLS TO CONTINUE STUDENT SAVINGS PROGRAM

More schools than ever before are planning a peacetime classroom savings program. For some this means a return to their pre-war bank plan. For thousands of others it means continuance of Stamp Day and new emphasis on lessons in personal money management and government financing so that boys and girls my realize the advantages of regular saving and may become interested shareholders in their Government.

War Bonds and Stamps will continue on sale under the name of U. S. Savings Bonds and Stamps. A weekly Savings Day in every school will give an opportunity for 30,000,000 young Americans to strengthen their habits of thrift by the steady purchase of Stamps or by regular deposits in their School banks toward eventual ownership of "a share in America."

NOTES FROM A MATHEMATICS CLASSROOM

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109. Deriving the Equation in Verbal Problems. One of the most interesting questions in the pedagogy of elementary algebra is that of teaching the class how to derive equations. An unusually good discussion of the nature of the difficulties is in Butler and Wren *Teaching of Secondary Mathematics*, p. 318–320. The difficulties are: (1) Pupils read too rapidly. (2) The relationships are often implied instead of stated explicitly (3) Reluctance of the pupils to organize the relevant data. (4) No single general pattern of attack exists.

No textbook can do anything about the first difficulty; teaching correct reading habits is the province of the teacher. The success of general methods (discussed in a NOTE in March 1944) depends on how well the pupil has overcome the other three difficulties.

A textbook can explain *how* to organize the relevant data, but many pupils refuse to do so. I say ***refuse*** because it is a simple thing to do, and requires no great mental effort. But with some classes only the most dire threats by the teacher will make the pupil follow the teacher's advice. This reluctance is well illustrated in *age* problems. Suppose we ask the pupil to write the present (assumed) age of each individual in the problem, and next to write the age of each individual at the other date mentioned in the problem, remembering that everybody will be n years older n years hence and was n years younger n years ago. The pupil is further advised to write these items *before* attempting to form an equation. But there are always some pupils who will not follow the teacher's advice; it seems that they make a wager with themselves that they are bright enough to get the correct equation by disregarding the teacher's advice or by doing the opposite of what the teacher says. This attitude is prevalent and inevitable in classes where many problems have been solved by algebra but could have been solved more easily by arithmetic. Evidently if the teacher always does things the hard way then the teacher's advice will seldom be followed. And we have here an example of the folly of doing by algebra those things that can be done more easily by arithmetic. A previous NOTE (June, 1944) discussed the danger of belittling algebra in the mind of the pupil.

The second difficulty mentioned by Butler and Webb is the principal one. On page 320 they say, "Therefore, somewhere in the problem, it should be possible to find at least one quantitative element for which two different mathematical expressions can be obtained." As some teachers say, "To make an equation, find two things equal to the same thing." Examining some of the current textbooks in algebra I found the pupil is advised as follows:

Betz *Algebra for Today* (1937), p. 108. "Try to discover two expressions or quantities which are equal, and then write the equation which expresses this relationship."

Edgerton and Carpenter *Elementary Algebra* (1943), p. 168, states merely "Form your equation." The problems are grouped into types and an example of each type is solved. This is the usual method in most texts for teaching how to derive the equation; it is hoped that from these types a pupil will learn how to attack any new type.

Hart *Progressive First Algebra* (1943). The problems are grouped in types. The preface states "specific instruction for solving each kind of problem (is given) when it appears."

Schorling-Clark-Smith *First Year Algebra* (1943), p. 251. "Formulate equations that express relations between quantities." And in the summary on page 258 it states as step 6, "Using the remaining relationship, write an equation."

Mallory *First Course in Algebra* (1943), p. 90 "Remember that an equation means that two things are equal in value. Hence see if you can put the algebraic statements into a form so that one part will balance the other, thus forming an equation."

Commenting on the one-type-at-a-time method, Butler and Webb, p. 320, say " . . . the advisability of teaching verbal problems by type seems, at best, questionable. It does tend to produce specific classroom results more quickly than any other method, but they are results which are more in the nature of specific skills rather than general powers." Here I am reminded of the boy who asked his father to draw a picture of an animal. When the father drew a horse, the boy protested, saying that he didn't want a horse but an animal. Likewise, the pictures of cows, dogs, and rabbits were unsatisfactory; the boy wanted an animal.

Even when I seek to teach a general method of procedure, I must begin with *some* problem, and *any* problem will be one of

its type. When the class has discussed this problem, it demands "Give us another like this one." Or, if demand is lacking, I can best check what has been learned by treating at least one more problem like it, or even two or three like it. The next day, still aiming at generality, I consider a different variety, and will very likely discuss two or three like it before considering a third variety. If no two problems were alike, only confusion would result. Then after considering three or four specific types I can safely assign a list of ten different problems. General powers grow out of specific skills. I cannot draw a picture of an animal.

110. Relations between Variables. It is possible to derive the equations for verbal problems by finding two expressions for a quantity and then equating the expressions. But I dislike that method because it does not emphasize sufficiently that every problem is a study of the relation between variables. My attitude is that every problem can be solved by writing algebraicly the relations between the variables. Briefly, my advice to the pupils is: "Write algebraicly the relations between the known and unknown quantities. When you have written all the relations, you will have the equation you want. If you haven't the equation, then you have overlooked some relation, and it is your task to find it."

For example, by the "things equal to the same thing" method a pupil would analyze a coin problem as:

n = number of nickels,
$n+3$ = number of dimes,
$5n$ = value of the n nickels,
$10(n+3)$ = value of the $n+3$ dimes,
$5n+10(n+3)$ = value of the nickels and dimes,
90 = given value of the nickels and dimes.
$5n+10(n+3)=90$.

My analysis would include steps 1, 2, 3, 4, and 6, and then obtain the equation by a substitution in, or a use of, the general relation: The value of the nickels plus the value of the dimes equals the value of the coins.

Likewise, for an investment problem, I would not say

$.05x+.06(4000-x)$ = income from investments,
75 = income from investments,
$.05x+.06(4000-x)=75$

but would say that the equation is a statement of the general

relation: The income from one investment plus the income from another investment equals the total income.

A mixture problem would use the relation: The actual amount of iodine in one solution plus the actual amount of iodine in another solution equals the amount of iodine in the combined solutions.

A work problem would be based on the two relations:

The amount of work done equals the number of working hours multiplied by the part accomplished per hour;

The work done by one person plus the work done by a second person equals the work done by the two persons.

Other fundamental relations are:

The value in cents of some nickels is 5 times the number of nickels.

Cost plus profit equals the selling price.

The cost of some wheat plus the cost of some oats equals the cost of the wheat and the oats.

The distance from A to B is the same, over the same road, in either direction.

This method emphasizes general relations between quantities and is a sound basis for general methods applicable to all types of problems. Hence, I tend to emphasize only problems in which there exists a general relation. Inversely, a problem that involves no general relations is a trivial problem and should be avoided as much as possible. Such a problem would be: Five added to 3 times a number is 26. (A few such exercises may be needed during the first month, but only a few). Problems about consecutive integers are also trivial since they involve only the simple relation that even (and likewise odd) integers differ by 2. Age problems are slightly more important, but even they teach only that n years from now we will be n years older.

If my theories are right, then we should introduce as early as possible the study of sets of equations since the pupil can then write the relations more easily. And certainly all such work should precede multiplication of monomials like $3x^2$ times $-6x^4y^3$, multiplication of binomials, long division, and some of the other formal operations.

At the beginning of the course either the textbook or the teacher must tell the class some of the general relations which are the bases for the equations. Later the pupil can be expected to find them. At least he should get the notion that when he cannot solve a problem it is because he is overlooking such a relation.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

MEETINGS OF THE BOARD OF DIRECTORS

The Board of Directors of the Central Association of Science and Mathematics Teachers met at 7:30 P.M. on Friday, November 23, 1945 in the Edgewater Beach Hotel in Chicago. Those present were: president Walter H. Carnahan, vice-president Joseph E. Dickman, secretary Harold H. Metcalf, treasurer Ray C. Soliday, historian Edwin W. Schreiber, and directors Emil L. Massey, Geraldine Reep Johnson, John Mayfield, J. T. Johnson, Arthur O. Baker, George E. Hawkins, Ruth W. Mikesell, Paul L. Trump, Charlotte L. Grant, Fred D. Leonhard, and J. E. Potzger. In addition, there were committee chairmen and other members of the association who gave reports and participated in the discussion. R. E. Park and Mary A. Potter, directors, were kept from attendance because of serious illness in their immediate families.

President Carnahan called the meeting to order and asked the secretary to read the report of the committee to study the matter of sectional meetings which was printed on pages 682–684 of the October issue of SCHOOL SCIENCE AND MATHEMATICS. Marie S. Wilcox, chairman of the committee, stated that the report was based on the answers to a questionnaire sent by the committee to 75 members of the association. She stressed that the housing of the convention was becoming more and more of a problem; that the appointment of the committee was an outgrowth of conversations with hotel managers during the war period in which the hotels took the position that the association required too much saleable space for small meetings, space that otherwise would be used for private parties, etc.; and that most hotels do not have enough Friday afternoon meeting rooms to accommodate the eight sectional meetings. Miss Villa B. Smith represented the geography section and referred to the paragraphs in the committee report which dealt with the geography section. The committee report states, "Only ten members listed geography as their subject in the 1944 yearbook. This small number of members hardly justifies a program on Friday afternoon in competition with other sectional meetings. If these ten members plan a program so outstanding that it draws a group of the membership to it, they are taking these members from other sections which deserve their support. Recognition could be given the members interested in geography on Saturday morning." Referring to the Saturday morning meetings, the committee continues: "one more possible combination is that of the geography section with the conservation section on Saturday morning." Miss Smith stated that the 1945 yearbook lists 28 geography members in addition to three who registered on Friday morning. In 1943, 64 attended the geography section meeting, in 1944, 131 attended and only two of these were members of other sections, and in 1945, 75 attended. Quite a number of those who attend the geography section pay the fifty cent registration fee for non-members. Miss Smith stated that when she received the questionnaire she was in no position to recommend the dropping of any section; she had always attended only the geography section and had always found it well attended. Miss Smith contended that the reason given by the committee for discontinuing sections, small membership, was inadequate in that no association could remain healthy which discouraged any part of an interested membership from attendance. Miss Smith read a letter from an association member which stressed the contribution geography has made to the war effort and the part it will play in the understanding of the world.

Miss Hildegard C. Pieper represented the elementary science section which is referred to in the committee report as follows, "only 14 members in the 194 yearbook gave elementary science as their teaching field and therefore the program of the section was planned primarily as a service to paying visitors. This worthwhile project can be continued by combining the program with that of the elementary school group on Saturday morning. On Firday afternoon, elementary teachers may attend the general science or elementary mathematics section." Further the committee recommends, "that the elementary science section from Friday afternoon be combined with the elementary school group meeting on Saturday morning with the title of elementary science group or section. Elementary mathematics is well taken care of on Friday afternoon and does not need a place on Saturday morning. The elementary science group should have an outstanding program and be well publicized and should be one of the features on Saturday morning." Miss Pieper stated that the elementary science section had presented a better program each year since its inception and that forty were turned away from the section meeting this year, the seventy-five in attendance filling the room to capacity. Mr. Carnahan suggested that the general science and elementary science sections might be combined on Friday afternoon.

Miss Smith recalled that our convention in 1944 at the Stevens Hotel in Chicago was competing with the international air conference and the CIO for space. Mr. Dickman and Mr. Massey agreed that our association might run into that difficulty again at any hotel.

Mr. Carnahan reminded the board that the Stevens Hotel, after contracting to take our convention, finding in August that the ODT probably would allow only 50 to attend from outside the Chicago area told us to look elsewhere for accomodations since the rooms reserved for us could be rented for $100 or more each.

Mr. Baker suggested that the troubles of the last few years might have been due mostly to difficulties traceable to the war effort; that 1,000 members indicate progress; that all sections are now working hard and that, until a real crisis develops, no section should be eliminated.

After continued discussion engaged in by quite a number of the group present, the problem was laid on the table for further consideration later.

Mr. George K. Peterson, chairman of the journal committee, gave the following information taken from the official audit of the books of the association for the fiscal year, July 1, 1944 to June 30, 1945: number of subscribers to SCHOOL SCIENCE AND MATHEMATICS, 2,952; total income from all sources, $10,311.53; total expenditures, $9,795.69; and net income from operations of $515.84 which is an increase over the previous year of $134.03. Mr. Peterson stated that the journal committee was very much pleased with the status of the association at the present time.

The journal committee is studying the possibilities of recognizing long membership in the association up to the time of retirement from teaching with a life membership.

A problem of concern to the association is the high percentage of turnover in subscribers to the journal and in association membership. How best serve the membership is a question of growing concern.

The journal committee commended Captain and Mrs. Soliday, Dr. Glen W. Warner and Mrs. Geraldine R. Johnson for their contributions to the success of the journal and of the yearbook.

Mr. Hawkins moved, Mrs. Mikesell seconded and it was passed that the journal committee give further attention to the problem of life memberships for long term membership in the association.

Captain Soliday presented a typewritten report of the business manager

and treasurer which is filed in the secretary's books with the official minutes. Pertinent information beyond that already referred to by Mr. Peterson includes: cash resources of the association on November 22, 1945 amount to $6,372.92; guest registration fees for the the last two conventions of $259.50 and yearbook profits of $421.28 have been very important in improving the financial position; an aggressive campaign for new advertising will be started as soon as paper becomes available for a larger journal; foreign circulation should increase as world conditions become more normal; and that a strong, continuous promotion program by mail and personal contacts is being developed. Captain Soliday raised the following questions: what may the association do, more than it is now doing, to insure maximum services and values to members and should the association extend its efforts to bring in members from states beyond those in the immediate area of operation?

The directors favored no limitation of area in seeking members.

Mrs. Geraldine Reep Johnson submitted a typewritten report which indicated profit to the association from the yearbook to be in excess of $500. She stated that the journal mailing list was of great help to her and suggested ordering from 500 to 800 more yearbooks next year.

Mr. Potzger told of the importance of getting the yearbook out before November 1st so that bills could be mailed to the advertisers on November 1st. He spoke of some of the difficulties the yearbook manager had to contend with and commended Mrs. Johnson for her excellent work.

Mr. Warner, editor of the association journal, reported that the war years had diminished the number of papers submitted for publication and urged the membership to do everything possible to improve the situation.

Mr. Fred Leonhard, chairman of the membership committee, submitted a typed report. He commended other members of the committee for the help during the year and at the convention. There are now 1,000 members of the Association widely distributed over the United States, eleven living in foreign countries. 515 members and 266 guests registered at the convention on Friday. There were 33 non-renewals of membership in December, 1944 and 135 in June, 1945. A follow up study and campaign is in progress. He showed a possible lapel name holder for the 1946 convention. The work of the committee is in the direction of enlarging the state committees, more attention to parochial teachers and widening the horizon of the work.

Mr. Haggard, local arrangements chairman, told of the work of the local committees. He was appreciative of the help given him by the various committee and association members and was especially thankful to the hotel for the way in which it cooperated in facilitating the work of putting on the convention.

Mr. Franklin Frey, chairman of the place of meeting committee, told of the considerations leading the committee to recommend Detroit as the city in which to meet in 1946.

Mr. Potzger moved, Mrs. Johnson seconded and it was passed that: Detroit be the place of meeting of the Central Association of Science and Mathematics in 1946.

Mr. J. T. Johnson explained that transportation of children to the elementary mathematics section meeting was to cost $14.50 which was more than the amount allowed by the board for such expense.

Mr. Potzger moved, Mr. Dickman seconded and it was passed that: the Association pay the expense item of $14.50 of the elementary mathematics section.

Mrs. Johnson moved, Mr. Hawkins seconded and it was passed that: The treasurer be instructed to pay all bills incidental to the running of the convention.

Mr. Emil Massey and Mr. Norman Jones spoke in support of a bill now in Congress that will give monetary support to the teaching of science in secondary schools. Mr. Massey was asked to prepare a resolution to be presented at the business meeting of the Association on Saturday morning.

The meeting was adjourned.

Respectfully submitted,
HAROLD H. METCALF, *secretary.*

THE SATURDAY MORNING BUSINESS MEETING

President Walter H. Carnahan called the meeting to order and called on secretary Harold H. Metcalf to read from a communication from a former president of the Association, Otis W. Caldwell. In part, Dr. Caldwell says, "There was never a time when it was more important that those concerned with science should rethink their relation to the entire program of public education. The achievements of science during the World War are matters of great pride but of still greater human responsibility. It will take the very wisest type of thinking to enable us to go forward to the end that science and its method may operate helpfully with all classes of human beings."

The resolutions committee gave the following report: The committee on resolutions wishes to offer for the consideration of the Association the following resolutions: (1) The Association wishes to express sincere thanks to its officers, directors, convention committees, section and group chairmen, and all others who have worked so hard to make this convention an outstanding success; (2) The Association wishes to express its appreciation to the management of the Edgewater Beach Hotel for the arrangements which have been exceptionally suitable; (3) The Association wishes to express appreciation for the time and effort spent by the various exhibitors, and speakers on both general and sectional programs. In partial recognition of this effort the Association instructs its secretary to send a copy of this resolution to each one concerned; (4) In recognition of the fact that 1950 will mark the golden anniversary of the founding of this Association, it is requested that from time to time the JOURNAL carry appropriate items which tend to keep this in the minds of the members and which informs them of the plans in progress; (5) The Association recommends to its board of directors a study of the advisability of establishing a permanent committee on policies with a view toward obtaining consistency and continuity in all Association activities. Respectfully submitted, Kenneth E. Vordenberg, chairman. Resolution read by Cecil B. Read.

A sixth resolution prepared by Emil Massey and Norman Jones was also read. It calls for the immediate attention and action of science teachers and is as follows: A bill, S 1316, known as the "High School Science Education Act of 1945" to further promote the national strength, security, and welfare by assisting the States and Territories in extending and improving courses of instruction in the natural sciences through public secondary schools, was presented in the Senate of the United States by Mr. Thomas of Utah on July 26, 1945 and referred to the Committee on Education and Labor.

Whereas the progress of our modern technological civilization in the United States is dependent on a widespread understanding of the principles and practical applications of the natural sciences; and

Whereas such an understanding of science principles and their applications constitute an indispensable element in the post war plans for national security and individual welfare; and

Whereas basic training in the natural sciences is of vital importance in the preparation of youth for many and various occupational fields; and

Whereas the war has disclosed a widespread lack of opportunity for

youth enrolled in public secondary schools to receive effective instruction in natural science subjects;

Now therefore be it resolved that the Central Association of Science and Mathematics Teachers go on record as supporting Senate Bill S 1316 and ask the Education and Labor Committee to report out this bill with the recommendation that it be passed;

Be it further resolved that copies of this resolution be forwarded to the Committee on Education and Labor and that members of the Association contact their respective senators urging passage of Senate Bill S 1316.

Mr. Read moved the adoption of the resolutions, it was seconded and passed.

Miss Royt pointed out that the Board of Directors of the Association constituted the policy making committee of the Association.

Mr. Ira Davis spoke in favor of the Association of Science and Mathematics Teachers using part of its funds to publish a Yearbook such as the one published by the *Mathematics Teacher*.

Mrs. Geraldine Reep Johnson reported on the Yearbook of the Association and predicted a profit of about $521. More information on her report will be found in the Board minutes.

Miss Royt suggested that next year's Yearbook include a section on what to do in the city in which the convention meets. Also, the Yearbook should contain information on the times at which the exhibits are to be open. She asked why the exhibits were not open on Friday night.

Mr. Potzger stated that it was former policy of the Association to keep the exhibits open on Friday night but that the attendance had been so small that the exhibitors had objected to the arrangement.

Mr. Peterson, in his report of the work of the journal committee, gave information that will be found in the minutes of the Friday night Board meeting. He stated that an examination of the prepaid subscriptions and advertizing indicated that both were on the up trend.

Mr. Vordenberg moved, it was seconded and passed that the report be accepted.

Captain Soliday reported a total convention registration of 781, 266 of whom were guests paying the 50 cent fee.

Mr. Warner, editor of the JOURNAL, told the membership that they owned the JOURNAL, asked them what they were doing of interest that could be written up, and urged that more papers be submitted for publication.

Mr. Warner also gave the report of the necrology committee in which the only death reported was that of Miss Ada Weckel, an account of her life being written up in the November JOURNAL. Mr. Warner said that in an Association as large as ours there are probably deaths of which the committee has not been informed.

Mr. Schreiber, Association Historian stated that page 55 of the Yearbook for the first time in the history of the Association had a complete and accurate report on offices held in the Association by the past presidents. Mr. Schreiber has a copy of all Yearbooks except the 1921 issue. He will appreciate a copy from any one who has saved it. Next year, Mr. Schreiber hopes to include data on all officers.

Mr. Franklin Frey, chairman of the place of meeting committee, brought in the recommendation of Detroit as the city in which to meet next year. Detroit will be the convention city unless problems develop which cannot be overcome.

Mr. W. R. Teeters, chairman of the nominating committee, made the following report: for president of the Association for 1945–46, Arthur O. Baker of Cleveland; for vice president, Charlotte Grant of Oak Park &

River Forest High School, Oak Park, Illinois; to take the place of Mr. Baker and serve for one year on the Board of Directors, H. E. Grime of the central office of the Cleveland Public Schools; to take the place of Charlotte Grant and serve for two years on the Board of Directors, Kenneth Vordenberg of the Cincinnati Public Schools; four directors to serve the full term of three years, Joseph E. Dickman, Board of Education, Chicago, Illinois; Fred W. Moore, Owosso, Michigan High School; Helen Rowe, Calumet High School of Chicago, Illinois; and Bjarne Ullsvik, State Normal University, Normal, Illinois. Mr. Teeters moved the adoption of the report, Mr. Schreiber seconded and it was passed.

C. F. Riddle of St. Louis, Missouri stated that this was his first trip to the convention and that he had some suggestions to make that might be of value to the Association. These will be relayed directly to president Baker.

The new president, A. O. Baker, spoke briefly of the challenge the presidency of the Association brought to him. He promised to do his best to guide the Association and to help plan a convention in keeping with the air and atomic energy age in which we are living.

The members gave president Carnahan a rising vote of thanks for the significant contribution he made to the Association through his leadership this year. President Carnahan spoke briefly of the excellent co-operation he had been given by everyone who had a part in the convention and of how much it had meant to him to serve the Association during the past year.

The meeting was adjourned.

Respectfully submitted,
HAROLD H. METCALF, *secretary.*

SATURDAY AFTERNOON BOARD MEETING

President Carnahan called the meeting to order. In attendance were Potzger, Leonhard, Grant, Trump, Mikesell, Hawkins, Baker, Massey, J. T. Johnson, G. R. Johnson, Mayfield, Dickman, Soliday, Metcalf, Vordenberg, Schreiber, Warner, Grime and Moore.

It was informally agreed that the convention return to the Edgewater Beach Hotel in Chicago two years hence.

President Carnahan adjourned the old Board and turned the chair over to the President-elect, Baker, who convened the new Board.

Mr. Potzger moved, Mrs. Johnson seconded and it was passed that Harold H. Metcalf serve as secretary.

Mr. Trump moved, Captain Soliday seconded and it was passed that the executive committee study the matter of formation of a policy committee and report to the Board on the matter at the spring meeting.

Mr. Potzger moved, Mrs. Mikesell seconded and it was passed that the executive committee study the advisability of a committee to study the by-laws of the Association and report back at the spring meeting.

Mr. Trump moved, Mr. Vordenberg seconded and it was passed that President Baker's nomination of Mr. Carnahan and Mr. Dickman to the executive committee, be approved.

Mr. Trump moved, Mr. Carnahan seconded and it was passed that the president withhold the appointment of Saturday morning meeting chairmen until the spring meeting of the Board at which time the matter of sections would again be taken up.

Mr. Hawkins moved, Mr. Leonhard seconded and it was passed that Mr. Warner investigate the possibilities of the Central Association being represented on the Co-operative Committee on Science Teaching. In case

of an invitation, the executive committee is empowered to select the representative or representatives. The meeting was adjourned.

Respectfully submitted,
HAROLD H. METCALF, *secretary.*

BRIEF REPORT ON THE 1945 CONVENTION

Fellowship among a group of men and women interested professionally in the teaching of boys and girls in the fields of science and mathematics was at its best in the meetings of the Central Association on November 23 and 24. From the stimulating atmosphere, one could feel that the war was over and that teachers once more were turning their attention to the broader principles of mathematics and science which apply in the normal lives of people in a democracy.

Most of the papers presented at the convention will appear in this and subsequent issues of the journal, SCHOOL SCIENCE AND MATHEMATICS. Every member of the Association and every subscriber to SCHOOL SCIENCE AND MATHEMATICS received a copy of the program in the Yearbook and therefore no attempt will be made here to outline the content of the various papers. The general and section programs were stimulating, were well attended and were good reason for the many remarks heard around the convention on Saturday, "See you at Detroit next year."

BIOLOGY SECTION

Mr. Ross Aeby, Chairman of the Biology Section of the Science and Mathematics Teachers, called the meeting to order on Nov. 23, 1945 at 2:30 P.M., in the North Room of the Edgewater Beach Hotel. He extended a hearty welcome to the members of both the Chicago Biology Round Table and the National Association of Biology Teachers.

The first speaker was the internationally famous physiologist and educator, Dr. Anton J. Carlson, professor Emeritus of the University of Chicago. His topic was "Some Current and Some Long Range Food and Nutrition Problems." Dr. Carlson related that the conclusion reached by the Food and Nutrition Congress held in Washington, D. C. before World War II was that between 30 and 40 million people in the United States actually suffered from malnutrition. The problem of an adequate diet in the midst of abundant food is complicated by the fact that no one yet knows what an optimum diet from birth to death should be. This constitutes one of the immediate problems in need of solution.

A second problem is the early diagnosis of malnutrition. At present, malnutrition can be determined only when it has gone far (i.e.) when pellagra or rickets make themselves apparent.

Habits that have long been established by man, such as the milling of flour, seemingly cannot be controlled entirely by better understanding. One wonders if understanding ever will compete with habits and emotions. We read of "enriched" bread, when actually it is still impoverished because we prefer it that way.

Finally, a long range solution to problems of nutrition must take into consideration the necessity of checking the reproductive capacity of the human population, which, like animals, tends to ultimately exceed the food producing capacity of the country.

The nominating committee consisting of Chairman, Arthur Smith, Central H. S., South Bend, Ind.; Miss Helen Trowbridge, Glenbard H. S., Glen Ellyn, Ill.; Mr. Andrew Stauffer, Wright Jr. College, Chicago; and Mr. Allen Meyer, Mackenzie H. S., Detroit, Mich. recommended the following as officers who, accordingly, were elected: Chairman—Fred J.

Burdine, Thornton Twp. H. S., Harvey, Ill. Vice-chairman—O. D. Roberts, Oak Park-River Forest H. S., Oak Park, Ill. Secretary—Helen Trowbridge, Glenbard H. S., Glen Ellyn, Ill.

The second speaker, a member of the National Research Council, Dr. Niel E. Stevens, Professor of Botany, University of Illinois, talked on "A New Slant on an Old Problem." The final solution to the old problem of how to determine the best method of doing a thing must be the simple expedient of using a technique too often overlooked by teachers of science, namely, the scientific method. For example, we have debated pro and con for years as to whether to teach Biology or Botany and Zoology. Let us now arrive at a solution by the only approach that can settle such a question. Dr. Stevens elaborated this idea by naming a number of other topics which are as yet undecided because it is easier to discuss the probable solution than to determine it experimentally.

The concluding speaker, Dr. F. W. Mohlman, Adjunct Professor of Sanitary Chemistry at Armour Institute of Technology and Director of Laboratories of the Sanitary District of Chicago spoke on "Modern Problems in Water Supply and Sewage Disposal." He illustrated his lecture with an excellent selection of photographs of the large scale equipment required in the treatment of water and wastes for a city the size of Chicago and its many suburbs. Diversion of lake water in quantities that run into hundreds of millions of gallons per day, and the rendering harmless of this same volume after use, presents the most expensive single application of biological knowledge today.

Detailed manuscripts by each of the above speakers will be made available for publication in this JOURNAL.

FRED J. BURDINE, *secretary.*

CHEMISTRY SECTION

Presiding: Mr. Fred W. Moore

Mr. R. W. Woline, Oak Park-River Forest Township High School of Oak Park, Illinois discussed effective Chemistry Teaching. He first summarized some of the poorer practices in the conventional high school chemistry course. The most of his discussion was given over to a description of the way students are taught to think for themselves in the Oak Park High School. Mr. Woline distributed an abundance of mimeographed material which is used in his own school.

Dr. H. B. Hass, Head of Chemistry Department, Purdue University, Lafayette, Indiana briefly reviewed the objectives of Science teaching.

Dr. Edward J. Matson, Research Chemist, The Abbott Laboratories, North Chicago, Illinois discussed some of the newer Drug Research which has been carried on in his laboratory. His paper will appear in a later issue of the JOURNAL.

The nominating committee consisting of W. Glenn Tilbury, John C. Chiddix and Emil L. Massey presented the names of the following persons who were unanimously elected: chairman, Walter C. Geisler; vice-chairman, Loren T. Lucas; and secretary, Allen F. Meyer.

LOREN T. LUCAS, *secretary.*

ELEMENTARY MATHEMATICS

The panel discussion on "What Is Problem Solving In Arithmetic" and the class demonstration by Irving Park Elementary School Pupils were very interesting to the large group of teachers who attended the meeting.

The officers elected were: chairman, Ross Herr; vice chairman, Albert H. Goodrich; and secretary, Marie W. Sperks.

Albert H. Goodrich served as secretary at the meeting. The papers will be published in a future issue of SCHOOL SCIENCE AND MATHEMATICS.

ELEMENTARY SCIENCE SECTION

Upper Grade Science Demonstration Lesson—by Laura Louise Watkins, Lincoln School, Cicero, Ill.

Miss Watkins taught a lesson on *Fire*. The problem was to determine what conditions are necessary for fire to burn. Through discussion and experimentation, the class determined that the following three things are necessary.

1. They must have a combustable material.
2. They must know something about the kindling point of the material.
3. There must be oxygen and a circulation of air.

The lesson was presented and carried out in a way which challenged the children to good thinking.

A Science Program for the Elementary Schools—by Bertha Parker, Laboratory School, University of Chicago

Miss Parker presented two film strips. The first one, with a sound accompaniment, brought to the meeting four science classes in action. The pictures had been taken in science classrooms without the children knowing they were being taken. The exposures were made at five second intervals. The second film strip presented suggestions for models and toys which might be made and used in the classroom to illustrate scientific principles or ideas. Miss Parker discussed each of the models or toys in relation to a unit of work.

Teaching Pupils to Become Better Thinkers—by Dr. Wilbur Beauchamp, Department of Education, University of Chicago, Chicago

Dr. Beauchamp pointed out that everybody thinks. The problem of the teacher is to guide and challenge the thinking of the pupils. She must set the conditions for good thinking. The teacher must give them something to think about. It must be simple and concrete.

1. The teacher must raise the problem in the mind of the pupil.
2. The teacher must motivate the children to carry through on their problem.

The problem could be raised in any one of several ways. Dr. Beauchamp suggested the following:

1. Questions
   a. Centered around the past experiences of children
   b. How some things happen
   c. Why some things happen
2. Doing experiments
3. Going on field trips or bringing the materials to the class room.

To carry through on the problem Dr. Beauchamp chose a problem on water evaporation. He showed that by asking questions and by doing experiments the principles and generalizations can be derived through guided thinking. He pointed out the importance of repetition when developing scientific concepts.

Hildegard Pieper was elected chairman and Illa Podendorf, vice-chairman for the section for the coming year. The secretary, to be announced later pending acceptance of office, will come from the Detroit area.

GENERAL SCIENCE SECTION

The first speaker was Mr. R. M. Bell of the Western Cartridge Company of East Alton, Illinois. Mr. Bell discussed the employee training system at his plant and related the success achieved as measured by decreases in absenteeism and labor turnover. His firm found that a carefully planned and executed two week course for new employees also resulted in an esprit-de-corps and increased happiness for the workers.

On the speaker's table were many samples of powder and brass shells, the principle products of Western Cartridge Company. These exhibits were passed among the audience while Mr. Bell related the manufacturing processes involved in their production.

The second speaker was Mr. J. F. Snodgrass, principal of the Community High School in Wood River, Illinois. Mr. Snodgrass, in his talk, emphasized the opportunity available to general science teachers to improve the language skills of their pupils. He warned, also, that teachers must be careful of their own oral and written expression.

The third scheduled speaker, Mr. John O. Burch of the Illinois State Department of Education, did not appear.

The nominating committee consisted of:
Mark P. Anderson, Junior High School, Watertown, Wisconsin
A. W. Henderson, High School, Wood River, Illinois

The committee nominated, and the group elected, the following officers:
Chairman: W. A. Porter, University High School, Madison, Wisconsin
Vice-chairman: Harold Z. Harris, Harper High School, Chicago, Illinois
Secretary: Howard Oetting, Community High School, Wood River, Illinois.

HAROLD Z. HARRIS, *secretary.*

GEOGRAPHY SECTION

The Geography Section met in the Ball Room of the Edgewater Beach Hotel, Friday afternoon, November 23. The meeting was attended by seventy-five Association members and friends, sixty-five signing the attendance roll.

The papers of the afternoon were presented by three outstanding authorities. Lantern slides, map displays and a question period contributed much to the success of the meeting. The number who stayed after the program to meet the speakers and continue discussions with them was evidence of interest in topics presented. The papers will appear in early issues of the JOURNAL.

"The Role of Air Transportation in the Future" was ably discussed by Brig. General M. W. Arnold of the Air Transport Command, Washington, D. C.

"Aviation Geography in the Oak Park High School" was discussed by Miss Helen Turner of the Oak Park-River Forest Township High School, Oak Park, Illinois.

"New Geographic Concepts of Man's Place in the World" was presented by Dr. Clyde F. Kohn of Northwestern University, Evanston, Illinois.

The following officers were elected for next year:
Chairman: Laura Kahler, Silver-Burdett Publishing Co., Chicago, Illinois
Vice-chairman: Mamie L. Anderzohn, Irving School, Oak Park, Illinois
Secretary: Laura L. Watkins, Lincoln School, Cicero, Illinois.

The nominating committee consisted of: Ruth Mikesell, Esther Arthur, Pearl Middlebrook.

LUCILLE KENNEY, *secretary.*

MATHEMATICS SECTION

Presiding: Miss Mildred Taylor, Fenger High School, Chicago
Other officers: Dr. J. M. Kinney, Chicago, Illinois (vice-chairman) Mr. H Vernon Price, Univ. High School, Iowa City (sec.)

After calling the meeting to order, the chairman called on Mr. C. A. Smith of Southwest High School, St. Louis, Mo., to take charge of the attendance records, and Miss Laura Chistman of Senn High School, Chicago, to take the notes of the meeting since the vice-chairman and the secretary could not be present.

A message of greeting and a paper on "Mathematics, the Language of Quantity" sent to the Mathematics Section by Dr. Halbert C. Christofferson of Miami University, Oxford, Ohio (who is temporarily teaching mathematics as a member of the University Training Command in Florence, Italy) was read to the group by Dr. Joseph Urbancek of the Chicago Teachers' College. In his paper Dr. Christofferson pointed out that Mathematics is a remarkable language of quantity, a complex, intricate network of meanings, and a system of closely related laws and techniques. He pointed out that these laws and techniques have a vast array of applications, that the applications are varied, boundless, and vital, and that the language of mathematics and the applications are wide, in fact, universal in scope. He cited several examples to emphasize the idea that he was presenting: namely, "Mathematics is a subject of vital importance to modern society. Its abstractions, its techniques, its modes of thinking, its laws penetrate widely and deeply into many phases of modern life. . . . Mathematics is not an ordinary language like Greek or Latin or English that may perish, but an everlasting language of quantity, a universal language through whose medium rare secrets can be discovered, a service language whose phrases, sentences, and implications can be found in nearly all aspects of life."

Dr. William Betz, specialist in mathematics, Rochester, New York, and a member of the Commission on Post-War Plans appointed by the National Council of Teachers of Mathematics, spoke on "Central Issues in the Program of Mathematics for a World at Peace." Outlining the hostility toward mathematics on the part of educational leaders during the two decades before the recent World War, Dr. Betz pointed out that in the majority of our states not a single hour of mathematics was required for graduation from high school and a moderate amount of arithmetic was declared to be sufficient for all but a few "specialists." "The war brought a rude awakening. The Armed Forces soon discovered a shocking state of unpreparedness, not only in secondary mathematics but in the rudiments of arithmetic. An heroic training program became necessary. The war revealed that both in war and in industry mathematics is our sharpest weapon of defense. The end of the war was hastened by the atomic bomb, the joint contribution of mathemtics and science. That fact alone, together with the coming industrialization of Russia and China, and the revolutionary readjustments demanded by a global economy in the air age we are entering, would make a continuance of our neglect of mathematics synonymous with national suicide. In February, 1944, the Commission mentioned above was organized for the purpose of studying the problem of mathematical instruction in the post-war world. The Commission published two reports the substance of which may be summarized as follows: We need a continuous, integrated program in mathematics extending from the primary grades through the junior college. A check list of basic mathematical objectives, constituting a definition of literacy in elementary mathematics, has been prepared. The teaching of arithmetic must be . . . made systematic, meaningful and thorough. The junior high school must

stress certain essentials on a nation-wide front. In the high school we need a two-track program. In addition to the traditional courses we must have a two-year course in general or basic mathematics which gives more attention to the 'functional' aspects of mathematics. We must eliminate non-essentials and stress meaning, understanding and mastery. . . . The experience of the Armed Forces in developing training films and other teaching aids should be utilized as far as possible. Above all, we need teachers whose training and outlook can cope with these new demands."

At this point in the meeting the chairman called for a report of the nominating committee that had been appointed prior to the meeting. Serving on this committee were Mr. E. G. Hexter of Belleville Township High School, Belleville, Ill., (chairman), Mr. Franklin Frey of Cass Technical High School, Detroit, Mich., and Mr. George E. Hawkins, Lyons Twp. Junior College, La Grange, Ill. The committee offered the following slate which was accepted unanimously by those present: *Chairman*, Mr. Glenn F. Hewitt, Von Steuben High School, Chicago; *Vice-Chairman*, Mr. H. Vernon Price, University High School, Iowa City, Iowa; and *Secretary*, Mr. Philip Peak, University High School, Bloomington, Indiana.

"Teaching Functional Thinking in Mathematics" was the title of the paper read by Dr. J. S. Georges, chairman of the department of mathematics at Wright Junior college, Chicago. Dr. Georges introduced his subject by stating that "in general, we have accepted the truth of the proposition that while the art of thinking may not be essential to living, it is extremely essential to human living." The development of the ability to think should be a primary objective of our educational system. "Again, if the art of functional thinking characterizes the scientific thinking of the individual, then it must be granted that the development of functional thinking should be a primary objective of our mathematical instruction." The speaker analyzed functional thinking in terms of six propositions and went on to explain that functional thinking is concerned in recognition, rationalization, and manipulation of relationships between quantities. "Without some degree of functional thinking in the ordinary affairs of life there is nothing in the mental process which merits the name thinking. In the strictest sense, to think at all means to think functionally." He pointed out that in mathematics we recognize four types of learning products,—recognitions, rationalizations or understandings, manipulations and appreciations,—that with the latter type of learning our classroom instruction is not primarily interested, but the other three should be considered whenever instruction is evaluated. By giving specific examples from arithmetic and algebra, such as the use of a table instead of flash cards in the teaching of addition, the use of analysis in the solving of equations and the teaching of the formula (a statement of functionality) and the value of a course in algebra built around eight significant algebraic functions, the speaker showed how functional thinking could be developed. Since mathematics classes are the best instructional means of attaining the goal of functional thinking, the mathematics teacher should accept the challenge with conviction and determination. "All the teacher needs is a belief in the significance of functional thinking, . . . a strong faith in mathematics, and an equally strong faith in his ability as a leader of men."

Approximately two hundred were present to hear these inspiring and thought-provoking papers. The meeting was adjourned at 4:50.

MILDRED TAYLOR

PHYSICS SECTION

The Physics Section made a conducted tour of the Municipal Airport under the direction of Miss Kathleen Power, Educational Representative of United Air Lines.

The members of the group witnessed "behind-the-scenes" work in the daily operation of an airport handling eighteen thousand planes a month. Among the operations explained and seen in operation were:

The C.A.A. Communications Center where hundreds of weather reports are received, transmitted and relayed each hour of the day. Some idea of the magnitude of these operations may be gained from the fact that a board of 1600 switches controls the multitudes of circuits operating the banks of teletype machines.

The United States Weather Bureau where reports received by the communications center plus local observations are used to make up weather charts and predictions every three hours. This bureau is also responsible for the issuance of storm warnings.

The C.A.A. Control Center, which is similar to a dispatchers office, is operated by the government to control all air traffic on the airways between the Cleveland and Des Moines Centers. Not only was the general set-up and control explained but a staff working in front of a large semicircular operations panel was observed as they kept a check on all planes in flight. A maximum of three minutes differential between plane position reported and actual location is allowed.

The Local Control Tower clears and lands all planes at the air port by means of four transmitters and an electric signal torch. All radio communications between the port and planes are recorded. At one time during our visit there were eighteen incoming planes within a twelve mile radius of the port to be brought in.

The business meeting was called to order by Chairman W. N. Smith of Technical High School, Cleveland at 4:00 P.M. in the auditorium of United Air Lines.

Mr. T. Lee, Jr., Superintendent of Training Programs for United Air Lines gave an inspiring address on "What Industry Expects a Student To Get from A High School Physics Course." This address will appear in a later issue of the JOURNAL.

The nominating committee made its report and the following were elected officers for the coming year: E. G. Plasterer, Huntington High School, Huntington, Indiana, Chairman; A. A. Geisert, Von Steuben High School, Chicago, Illinois, Vice-Chairman; and R. W. Lefler, Purdue University, Lafayette, Indiana, Secretary.

The Committee on Curriculum and Teaching Materials presented its report. It was moved and seconded that the committee—P. A. Tapley, Chairman; J. H. McClelland; and R. W. Lefler continue its work for another year. Motion carried. An invitation for volunteer committee members and suggestions on curriculum and text-books was made. Address Mr. Tapley at 8110 S. Crandon St., Chicago, Illinois.

ANTONE A. GEISERT, *secretary.*

NEW ELEMENTS ANNOUNCED IN 1945

Discovery of elements 95 and 96, made by bombardment of Uranium 238 and Plutonium 239 with high energy alpha particles, was announced, thus raising to four the number of trans-uranic elements discovered as the result of the atomic bomb research.

Discovery of Neptunium 237, an isotope of element 93, was announced.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. N. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1944. *B. Felix John, Philadelphia, Pa.*

1945. *Proposed by Brother Felix John, Philadelphia, Pa.*

The arithmetic mean between M and N and the geometric mean between a and b are each equal to $Ma+Nb/M+N$. Find M and N in terms of a and b.

Solution by Hugo Brandt, Chicago

$$\frac{M+N}{2}=\sqrt{ab}, \quad \text{also} \quad \sqrt{ab}=\frac{Ma+Nb}{M+N}. \tag{1}$$

Hence

$$M+N=2\sqrt{ab} \tag{2}$$

$$Ma+Nb=\sqrt{ab}\,(M+N)=2ab. \tag{3}$$

Solving (2) and (3) for M and N:

$$M=\frac{2b(a-\sqrt{ab})}{a-b}$$

$$N=\frac{2a(\sqrt{ab}-b)}{a-b}.$$

Solutions were also offered by Roy Dubisch, Missoula, Mont.; Margaret Comstock, Ferndale, Mich.; Walter R. Warne, Columbia, Mo.; Brother U. Alfred, Napa, Calif.

1946. *Proposed by Clarence R. Perisho, McCook, Neb.*

A cylindrical standpipe H feet high stands on level ground, and is full of water. At what height above the ground should a hole be drilled so that the horizontal stream of water issuing from the hole will strike the ground at the greatest distance from the base?

Solution by the Proposer

If the hole is h feet above the ground, the head of water above the hole will be $H-h$, and the velocity of the water as it leaves the hole will be

$$\sqrt{2(H-h)g}.$$

The distance the water travels horizontally would be

$$D=\sqrt{2(H-h)g}\cdot t. \tag{1}$$

The time t is determined by the time it takes the water to fall h feet and is determined from

$$h=\tfrac{1}{2}gt^2 \quad \text{or} \quad t=\sqrt{\frac{2h}{g}}. \tag{2}$$

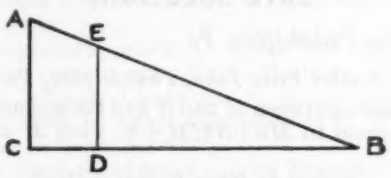
Substituting this value in (1) we have

$$D=\sqrt{4Hh-4h^2}$$

For D to be a maximum $dD/dh=0$. By carrying out this differentiation $H-2h=0$, or $h=H/2$.

Solutions were also offered by V. H. Paquet, Tigard, Ore.; Hugh Brandt, Chicago; Helen M. Scott, Baltimore, Md.; Brother U. Alfred, Napa Calif.,

1947. *Proposed by W. R. Warne, Marshall, Mo.*



In triangle ABC, with $C=90°$, and ED parallel to AC, if $CD=10$, $ED=15$, and if $AB+BC=100$, find BD.

Solution by V. H. Paquet, Tigard, Ore.

Referring to the figure, let $AB=y$, $BC=x$, and $AC=z$.
We have in $\triangle ABC$,

$$y^2-x^2=z^2. \tag{1}$$

From similar $\triangle BDE$ and BCA, we have

$$\frac{x-10}{15}=\frac{x}{z}, \quad \text{whence} \quad z^2=\frac{225x^2}{x^2-20x+100}. \tag{2}$$

From (1) and (2), we have

$$y^2-x^2=\frac{225x^2}{x^2-20x+100}. \tag{3}$$

From $y+x=100$, we have

$$y^2-x^2=10000-200x. \tag{4}$$

From (3) and (4), we have

$$(10000-200x)(x^2-20x+100)-225x^2=0.$$

Whence

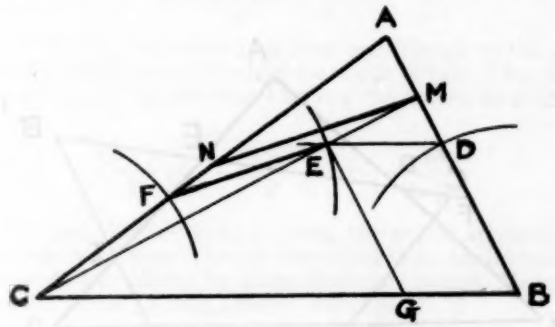
$$x^3-68.875x^2+1100x-5000=0.$$

This equation has one positive root, and two negative roots.
It must be solved by Cardan's method, or by trigonometry.
The positive root is 48.2091 −, and is therefore the length of BC.

$$\therefore \quad BD=BC-10=38.2091-.$$

Solutions were also offered by Isadore Gosz, West DePere, Wis.; Hazel Wilson, Annapolis, Md.; Helen M. Scott, Baltimore, Md.; Brother U. Alfred, Napa, Calif.; Hugo Brandt, Chicago.

1948. *Proposed by J. C. Ward, Chicago, Ill.*



The sides AB and AC of a triangle are cut by a line in points M and N respectively, so that $BM=MN=NC$. Construct the line.

Solution by V. H. Paquet, Tigard, Ore.

Case I. Point M falls on side AB.

Referring to the figure, with a radius somewhat less than AB, and with B and C as centers, strike arcs cutting BA and CA respectively, in points D and F. From D draw an indefinite line parallel to BC. With same radius $FE=BD=CF$, cut said parallel line in point E. Draw FE. Draw GE parallel to BA. Draw a straight line from C through E, and extend it to cut BA in point M. From M draw MN parallel to FE, and MN is the required line.

Proof: By construction and from parallelogram $BDEG$, $CF=FE=EG=BD$. By construction, $\triangle CFE$ is similar to $\triangle CNM$, and $\triangle CEG$ is similar to $\triangle CMB$. Whence

$$\frac{CF}{FE}=\frac{NC}{MN}, \qquad \frac{CE}{GE}=\frac{CE}{BM}, \quad \text{and} \quad \frac{CE}{FE}=\frac{CM}{MN}.$$

Whence $BM=MN=NC$.

Since MN is the only line that can be drawn to meet the construction conditions, it is the required line.

Case II. Side $BA < AC/2$, and point M falls on the extension of side BA. The construction and proof are the same as in Case I. MN is outside the triangle CAB.

Solutions were also offered by Helen M. Scott, Baltimore, Md.; Hazel S. Wilson, Annapolis, Md.; Margaret Comstock, Ferndale, Mich.; Hugo Brandt, Chicago; Adrian Struyk, Paterson, N. J.; Isadore Gosz, West DePere, Wis.

Note: Problem 1948 appears in Altschiller-Court's *College Geometry* art. 47.

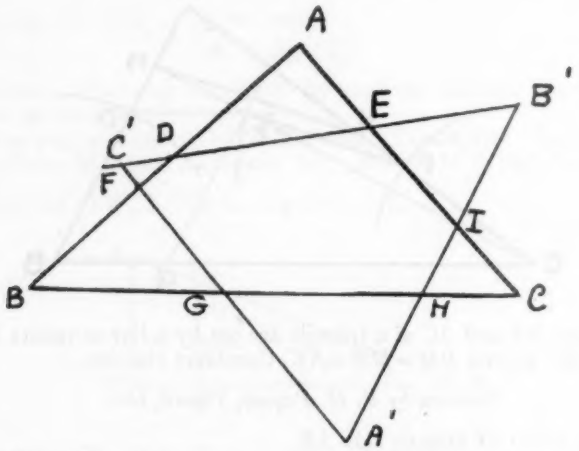
1949. *No solution for this issue.*

1950. *Proposed by Brother U. Alfred, Mont La Salle, Napa, Calif.*

Given any triangle ABC. On AB and AC cut off equal segments from A on the same side of A and connect the end points of the segment by a line. Proceed similarly for the other two pairs of sides. The three lines thus obtained form a triangle.

Operate similarly on this new triangle and continue this process.

What can be said about the angles of the successive triangles thus produced? What sort of triangle is approached in the limit?



Solution by the Proposer

In the figure

$$AD = AE$$

$$BF = BG$$

$$CH = CI.$$

Hence

$$\angle ADE = 90 - A/2$$

$$\angle BFG = 90 - B/2$$

and

$$C' = 180 - (90 - A/2 + 90 - B/2)$$

or

$$C'=\frac{A+B}{2}.$$

Similarly

$$A'=\frac{B+C}{2}$$

$$B'=\frac{C+A}{2}.$$

The differences of these angles are:

$$A'-B'=\frac{B-A}{2}$$

$$B'-C'=\frac{C-B}{2}$$

$$C'-A'=\frac{A-C}{2}$$

from which it follows that as we pass from one triangle to the next in the series, the differences among the angles are cut in half. Thus for the nth triangle thus formed, the differences among the angles would be numerically equal to

$$\left|\frac{B-A}{2^n}\right|, \quad \left|\frac{A-C}{2^n}\right|, \quad \left|\frac{C-B}{2^n}\right|.$$

Hence in the limit, the differences among the angles approach zero and thus the triangle itself approximates ever closer to an equiangular triangle.

Solutions were also offered by Hugo Brandt, Chicago; Margaret Comstock, Ferndale, Mich.; Adrian Struyk, Paterson, N. J.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in his department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1940. Hope Sabella, Convent Station, N. J. and Edwin Willin, Jr., Stevens Point, Wis.

EDITOR'S NOTE: It is again possible to send to a high school student, who has independently worked a problem and sent in a solution, a copy of the magazine showing this contribution. The teacher should certify the above stated conditions. A limited number of magazines are set aside for this purpose.

PROBLEMS FOR SOLUTION

1963. *Proposed by Grace Marsh, Mexico City, D. F.*

If $\cos 2y=\tan(45-x)$, show then $\tan x=\tan^2 y$.

1964. *Proposed by Lillian A. MacDonald, Newark, N. J.*

If S_p is the sum of the pth powers of the first n consecutive integers, then $9(S_3-S_4)$ divided by $5(S_4-S_2)$ equals the square of a whole number.

1965. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the system

$$\begin{aligned} x-y+z+w &= 8 \\ x^2+y^2-z^2-w^2 &= 36 \\ xy+zw &= 42 \\ x^3-y^3-z^3-w^3 &= 0 \end{aligned}$$

1966. *Proposed by Isaac Conley, Richmond, Va.*

The base of a triangular pyramid, $V-ABC$, in an equilateral triangle. If the faces are inclined at an angle of θ to the base, show that the angle between the lateral edges is 2 arc tan $(\sqrt{3}\cos\theta)$.

1967. *Proposed by Nellie Bishop, Seneca Falls, N. Y.*

In triangle ABC, if P is a point such that $BP=a/4$, show that $\tan BAP=\sqrt{3}/7$.

1968. *Proposed by Blanche Yerkes, Bearytown, New York.*

If $AB=BC$ in triangle ABC, and if D is the mid point of DC, show. without use of tables, that

$$\cot DAC=3.$$

THE ADDITION FORMULA FOR TANGENTS AGAIN

C. SOLOMON

Samuel J. Tilden High School, Brooklyn, N. Y.

In the December 1945 issue of SCHOOL SCIENCE AND MATHEMATICS, L. H. McFarlan gives a direct proof of tan $(x+y)$. There are other ways of doing this, but using this drawing we can have a much simpler proof, as follows:

$$\tan(x+y)=\frac{MR}{OM}=\frac{(t_1+t_2)\cos x}{OM}=\frac{\frac{1}{OP}(t_1+t_2)}{OM}=\frac{t_1+t_2}{OM\cdot OP}=\frac{t_1+t_2}{OQ\cdot OL}.$$

Since quadralateral $LMPQ$ is circumscribable, the product of the whole secant by its external segment is constant; or from the similarity of the triangles OQP and OML

$$\tan(x+y)=\frac{t_1+t_2}{OQ(OQ-LQ)}=\frac{t_1+t_2}{1(1-LQ)}=\frac{t_1+t_2}{1-LQ}=\frac{t_1+t_2}{1-t_2\tan x}=\frac{\tan x+\tan y}{1-\tan x\tan y}.$$

Oh, square thyself for use! a stone that may fit in the wall, is not left in the way.—WILLIAM R. ALGER.

BOOKS AND PAMPHLETS RECEIVED

THE MILKY WAY, by Bart J. Bok, and Priscilla F. Bok. Second Edition. Cloth. Pages vi+224. 14.5×21.5 cm. 1945. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

MEN OF MATHEMATICS, by E. T. Bell, *Professor of Mathematics, at the California Institute of Technology*. Cloth. Pages xxi+592. 13.5×21 cm. 1937. Dover Publications, 1780 Broadway, New York 19, N. Y. Price $2.75.

THE DEVELOPMENT OF MATHEMATICS, by E. T. Bell, *Professor of Mathematics, California Institute of Technology*. Second Edition. Cloth. Pages xiii+637. 14×22 cm. 1945. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $5.00.

ALGEBRA, A SECOND COURSE, by R. Orin Cornett, Ph.D., *Lecturer on Electronics, Harvard University*. Cloth. Pages xiii+313. 14×22 cm. 1945. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.00.

MATHEMATICS WE USE, Books One and Two by Leo J. Brueckner, Professor of Education Administration and Supervision, University of Minnesota; Foster E. Grossnickle, Professor of Mathematics, New Jersey State Teachers College; and Book Three by the above Professors and Fred L. Bedford, Associate Professor of Mathematics, New Jersey State Teachers College. Cloth. Book One, 319 pages, Price $1.00, Book Two, 320 pages, Price $1.00, Book Three, pages viii+437. Price $1.32. 13.5×19.5 cm. 1945. The John C. Winston Company, Philadelphia 7, Pa.

ROCKS AND RIVERS OF AMERICA, by Ellis W. Shuler, Southern Methodist University, Dallas, Texas. Cloth. 315 pages. 15×23.5 cm. 1945. The Jaques Cattell Press, Lancaster, Pa. Price $4.00.

BRAZIL, ORCHID OF THE TROPICS, by Mulford B. Foster, and Racine Sarasy Foster. Cloth. Pages xi+314. 15×23.5 cm. 1945. The Jaques Cattell Press, Lancaster, Pa.

TABLES OF ASSOCIATED LEGENDRE FUNCTIONS, Prepared by the Mathematical Tables Project. Conducted under the Sponsorship of the National Bureau of Standards. Present Volume begun under the Auspices of the Work Projects Administration for the City of New York and Completed with the Support of the Office of Scientific Research and Development. Lyman J. Briggs, Director, National Bureau of Standards official Sponsor, and Arnold N. Lowan, Project Director, Mathematical Tables Project. Cloth. Pages xlvi+306. 18×26.5 cm. 1944. Columbia University Press, New York, N. Y. Price $5.00.

CAREERS FOR GIRLS IN SCIENCE AND ENGINEERING, by Evelyn Steele, *Director, Vocational Guidance Research and Vocational Editor, Scholastic, the National High School Weekly*. Cloth. 189 pages 13.5×20.5 cm. 1943. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.50.

YOUR CAREER IN ENGINEERING, by Norman V. Carlisle, *Vocational Editor*, Scholastic, *The National High School Weekly*. Cloth. 253 pages. 13.5×20.5 cm. 1942. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.50.

YOUR CAREER IN CHEMISTRY, by Norman V. Carlisle, *Vocational Editor*, Scholastic, *The National High School Weekly*. Cloth. 251 pages. 13.5×20.5 cm. 1943. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.50.

CAREERS IN SCIENCE, by Philip Pollack in Collaboration with Vocational Guidance Research, Evelyn Steele, Director. Cloth. 222 pages. 13.5×20.5 cm. 1945. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.75.

CAREERS FOR WOMEN IN BANKING AND FINANCE, by Dorcas Campbell, *Instructor at New York University*. Cloth. 260 pages. 13.5×20.5 cm. 1944. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.75.

THE PLACE OF SCIENCE IN THE EDUCATION OF THE CONSUMER. A Statement Prepared for the Consumer Education Study of the National Association of Secondary-School Principals, by The National Science Teachers Association. Paper. 32 pages. 15.5×23.5 cm. 1945. The Consumer Education Study, 1201 16th Street, N.W., Washington 6, D. C. Single copies free on request, Additional Copies 15 cents each.

INSTITUTE OF INTERNATIONAL EDUCATION. Twenty-Sixth Annual Report of the Director. Paper. 90 pages. 15×23 cm. Institute of International Education, Inc., 2 West 45th Street, New York 19, N. Y.

POSTWAR EDUCATION OF NEGROES. Report of a Conference Sponsored by the U. S. Office of Education, by Ambrose Caliver, Senior Specialist in the Education of Negroes. Paper. Pages vi+71. 14.5×23 cm. Office of Education, Washington 25, D. C.

THE UNIVERSITY, An Address to the Citizens Board by Robert M. Hutchins, Chancellor of The University of Chicago, Paper. 13 pages. 12.5×18.5 cm.

THE TRANSITION FROM AM TO FM BROADCASTING. Statements of Paul E. Kesten, *Executive Vice President*, and Frank Stanton, *Vice President and General Manager, of Columbia Broadcasting System*, Inc. Submitted on July 30, 1945 to the Federal Communications Commission, Washington, D. C. Paper. 44 pages. 18×25 cm. The Columbia Broadcasting System, 485 Madison Avenue, New York 22, N. Y.

BOOK REVIEWS

ELECTRONICS DICTIONARY, by Nelson M. Cooke, Lt. Com., U.S.N. *Executive Officer, Radio Matériel School, Naval Research Laboratory, Washington, D. C.*, and John Markus, *Associate Editor, Electronics*. Cloth. Pages viii +433. 14×22.5 cm. 1945. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $5.00.

This is a new book for all interested in electronics and in industries using electronic equipment. It is up-to-date, clear-cut, authentic in every detail. It is of course not complete. In a rapidly developing subject new words and phrases are being coined daily. But comparatively few words, phrases, or abbreviations will be encountered that are not explained here. A total of over 6000 definitions and descriptions are given, with more than 600 illustrations consisting of pictures, wiring diagrams, section diagrams, charts, curves, phantom diagrams, etc. It includes the language of all radio com-

munication, telephone, telegraph, television, radar, industrial electronics, facsimile, and sound recording. Many of the discussions include, in addition to a good clear definition, many additional facts giving the use or application, and often a diagram or picture. This book will be of great value to the many technical workers and students in the rapidly expanding field of electronics.

G. W. W.

TEXTBOOK OF ORGANIC CHEMISTRY, by E. Wertheim, Professor of Organic Chemistry in the University of Arkansas. Second Edition. Cloth. Pages xiv+867. 15×23 cm. 1945. The Blakiston Company, 1012 Walnut Street, Philadelphia 5, Pa. Price $4.00.

The revised *Textbook of Organic Chemistry* has the same general purpose and plan as had the first edition published in 1939. Revision has enabled Mr. Wertheim to bring his text material up to date, to reorganize the order of presentation, and to add new instructional aids. Particularly excellent are the two color plates of molecular models of organic substances.

The book is designed for a two semester introductory course in organic chemistry and is equally adaptable to the needs of chemistry majors, premedics, and engineering students. It includes a wealth of material clearly and concisely presented.

The general order in each chapter is structure, nomenclature, isomerism, physical properties, preparation, proof of structure, reactions, important members of the series, and identification. To obviate detailed descriptions of individual compounds, the physical properties and constants for a whole series of homologs are given in tabular form.

An interesting feature of most chapters is a full page chart showing the chemical relationships of the most important member of the series. The review questions are graduated as to difficulty and include numerical problems as well as typical organic questions.

Two outstanding aspects of this text are chapter references to current periodicals and a series of portraits and short biographies of present day as well as earlier organic chemists.

The appendix covers fifty pages and includes such noteworthy features as a number of industrial flow sheets, glossary, chronological table, lists of organic radicals, and a table of physical constants of organic compounds. It is to be regretted that the author terminates his list of milestones in the development of organic chemistry with the year 1935.

From any standpoint this is an excellent book. The form is good, the type is clear, and the presentation is such that initial learning is made easy.

A. L. BURLINGAME
Chicago City Junior College, Wilson Branch

DISCOVERY OF THE ELEMENTS, by Mary Elvira Weeks, *Research Associate in Scientific Literature at the Kresge-Hooker Scientific Library, Wayne University*. Fifth Edition. Cloth. Pages xiv+578. 15×23.5 cm. 1945. *Journal of Chemical Education*, 20th and Northampton Streets, Easton, Pa. Price $4.00.

In her new fifth edition Miss Weeks continues her noteworthy work of presenting the discovery of the elements in a scientific, historically accurate, yet intensely interesting fashion. This latest edition is one hundred pages longer than the previous one and contains more information on the ores in which the elements were discovered. Additional space is devoted to the periodic chart. The material on many of the elements has been extensively revised and lengthened.

The book is illustrated with portraits and reproductions of pages of original manuscripts. Thumbnail biographies and quotations from original manuscripts augment the descriptive material. In this edition many of the quotations, formerly given in the original language, now appear in the English translation.

The work of Latin-American chemists, all too frequently ignored, receives adequate attention. The chronological table, over twelve pages long, extends from the sixteenth century to December 7, 1941.

The section on artificial radioactivity presents an interesting account of the discoveries which led to the atomic bomb. This reviewer is looking forward to the sixth edition and Miss Weeks' treatment of neptunium and plutonium.

A. L. BURLINGAME

ELEMENTS OF CHEMISTRY, by Raymond B. Brownlee, Robert W. Fuller, William J. Hancock, Michael D. Sohon, and Jesse E. Whitsit. Cloth. Pages vii+684+21. 13×19.5 cm. 1943. Allyn and Bacon, 2231 South Park Way, Chicago 16, Illinois.

This book, one of a series of texts by the same authors, is not merely revised but thoroughly rewritten. Many high school chemistry teachers will be pleased with the authors' return to the chapter method of presentation.

Chemical principles and theories are stressed. The explanation of difficult topics is based upon everyday experiences of high school students.

The authors constantly present the practical as well as the theoretical aspect of chemistry. Student interest is maintained by skillful writing and constant application of chemical principles to industrial problems. The material of the text is up to date. Such topics as plastics, synthetic rubber, photochemistry and nuclear reactions are adequately discussed.

The text is illustrated with many photographs and drawings. The print is unusually clear. The questions that follow each chapter are on the whole descriptive. A summary at the end of each chapter furnishes the student with an outline of the important points covered in the text material. A feature of the appendix is a table of isotopes of some of the more common elements.

A. L. BURLINGAME

MULTI-SENSORY AIDS IN THE TEACHING OF MATHEMATICS: THE EIGHTEENTH YEARBOOK OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS, compiled by the Committee on Multi-Sensory Aids. Pages xv+455. 1945. Bureau of Publications, Teachers College, Columbia University, New York.

The Committee on Multi-Sensory Aids of The Council of Teachers of Mathematics has compiled a comprehensive study and report on visual aids which have been found to be of practical help in the teaching of mathematics. Perhaps a list of the topics covered will give the reader a better picture of the report than any attempt to evaluate the materials presented in the Yearbook. The Topics are:

1. Multi-Sensory Aids
2. Drawing and Design
3. Demonstrations and Exhibits
4. Models and Devices
5. Instruments and Tools
6. Materials for Construction of Models
7. History of Models and Devices

8. Slides, Films, Three-Dimensional Projection, and Equipment
9. Appendix, containing descriptions of models and devices, and a bibliography of books, periodicals and films.

The present Yearbook follows the pattern of its predecessors. Under the editorship of Professor W. D. Reeve the contributions of the various members of the Committee and other cooperating teachers are presented in a volume having the unity of purpose and style. The teachers of mathematics in secondary schools will find in the book a wealth of suggestions for the use of visual aids in the teaching of mathematics.

J. S. GEORGES
Chicago City Junior College, Wright Branch

AN INTRODUCTION TO MATHEMATICS FOR TEACHERS, by Lee Emerson Boyer, *Millersville State Teachers College, Millersville, Pennsylvania.* Cloth. Pages xvii+478. 13.5×21.5 cm. 1945. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y. Price $3.25.

In the preface of the book the author states that the book is intended to provide prospective elementary and secondary school teachers some means of learning about the nature, significance and use of mathematics from early times to the present. This purpose sounds like a tremendous task for any author and it is. The topics and concepts which one author would select from arithmetic, algebra, geometry, and trigonometry as portraying the significance and uses of mathematics would differ greatly from those selected by another author. The reviewer is not an exception, and we must accept the author's choice of topics if the book is intended as a "popular" book for the layman. However, the book is a text and is intended for students, evidently students in a state teachers college, though this point is not explicitly made clear.

According to the author, the subject-matter content is couched in a historical setting, thereby calling the attention of the reader to the part that mathematics has played in the development of our civilization. Such materials are indeed interesting and are well presented by the author. However, they will not develop the mathematical power of the student, which fact is recognized by the author, when he says that "casual mental browsing without disciplined study will never greatly sharpen it." One wonders how the materials of the book will sharpen this mathematical power, if the instructional materials of the regular texts in arithmetic, algebra, and geometry have failed to do so. For the instructional materials of the book are selections from similar materials presented in texts on arithmetic, algebra, geometry, and trigonometry.

The teacher of secondary school mathematics will find excellent reference materials in the book.

J. S. GEORGES

THE ELECTROLYTIC CAPACITOR, by Alexander M. Georgiev, *Member, American Institute of Electrical Engineers.* Cloth. Pages xii+191. 15×23 cm. 1945. Murray Hill Books, Inc., 232 Madison Avenue, New York 10, N. Y. Price $3.00.

The electrolytic capacitor has become of increasing practical use in electronic circuits during the past two decades, because of its large capacitance for relatively small volume and low cost. The improvement and application of this type of capacitor has been so rapid that little has been written of a résumé nature covering its theory and development. The student and engineer has had to resort to periodical literature for this information and

will welcome this new book, *The Electrolytic Capacitor* by Alexander M. Georgiev.

This text presents a comprehensive description of the construction and functioning of the various types of electrolytic capacitors. Comparisons are made with the paper-wax and oil-paper capacitors. The relative advantages and limitations of the electrolytic capacitor are pointed out and possible defects are enumerated and their causes and means for prevention are discussed.

The author deals thoroughly with the theoretical and practical aspects of the dielectric film and also discusses equipment and process of forming the film. Methods of electrical measurement and routine tests on the electrolytic capacitor are also treated.

The form of the book is excellent. There are many line diagrams of parts and circuits as well as photographs of parts and equipment. Much valuable data and graphs are given. A very complete bibliography is given, including both books and periodicals, as well as a complete list of domestic and foreign patents issued pertaining to the subject.

The treatment as a whole is very comprehensive and should save the student, engineer, teacher or research worker considerable time in studying the background and modern applications of this important and practical device.

H. R. VOORHEES
Chicago City College, Wilson Branch

SCIENCE PROGRESS DURING THE WAR

Watson Davis
Director, Science Service

Energy from within the atom used in the atomic bomb is the most important advance in science announced in 1945 with world-shaking consequences. Possibility that atomic bombs will aid the elimination of future wars or make the next world conflict a danger to civilization's continuance has projected science into first place in international affairs.

Science summaries for 1940, 1941, 1942, 1943 and 1944 need additions due to advances kept secret. Achievement of the first cyclic nuclear reaction in 1942 ranks with the discovery of fire. Four new chemical elements have been added to the 92 previously known and one of these, 94, or plutonium, is the material most effectively used in the atomic bomb.

No less important are the by-products of nuclear fission, including the large variety of radioactive products not completely revealed that promise major medical treatments and explorations of cancer and other diseases and the industrial use of chemical production methods developed in the $2,000,000,000 atomic bomb project.

War applications of electronics, including radar, the proximity fuze using radar principle, loran which is a radio navigation system, perfected radio communication methods, and other developments were announced with the promise of many peacetime uses.

Among the health advances were several treatments for diseases unconquered, use of influenza vaccine on a large scale, an antidote for arsenic and bichloride of mercury, two promising rat poisons, continued application of DDT.

First legislative steps were taken toward a federally supported national research foundation.

THE SILVER ANNIVERSARY SERVICE RECORD OF THE OFFICERS OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS, INC. 1920–1945

Compiled by EDWIN W. SCHREIBER, *Secretary*
State Teachers College, Macomb, Illinois

Allen, Gertrude E., Univ. H. S., Oakland, Calif., D22, 23, 24.
Austin, C. M., Oak Park H. S., Ill., P20, D21, 22, 23, 24, 25, 26, V-P27, 28, D30, 31, 32, 40, 41, 42.
Austin, William A., High School, Fresno, Calif., D20, 21.
Barber, Harry C., English H. S., Boston, Mass., D25, 26, 27, P28, 29, D30, 31, 32, 33, 34, 35.
Beatley, Ralph, Sch. of Educ., Harvard Univ., Cambridge, Mass., V-P33, 34.
Beck, Hildegard R., McMichael Intermediate, Detroit, Mich., D40, 41, 42, 43, 44, 45.
Beck, William E., High School, Iowa City, Iowa, D20.
Bell, Kate, Lewis and Clark H. S., Spokane, Wash., D38, 40, 41, 42, 43.
Betz, William, Pub. Sch., Rochester, N. Y., D27, 28, 29, 30, 31, P32, 33, D34, 35, 36, 37, 38, 39.
Bixby, Florence A., Riverside H. S., Milwaukee, Wis., V-P24.
Breslich, Ernst R., Sch. of Edu. Univ. of Chicago, Ill., D36, 37, 38, V-P39, 40.
Cassidy, Lorena E., Wichita H. S., East, Wichita, Kans., D45, 46, 47.
Charlesworth, H. W., East H. S., Denver, Colo., D40, 41, 42, 43, 44, 45.
Christofferson, H. C., Miami Univ., Oxford, Ohio, D34, 35, 36, 37, P38, 39.
Clark, John R., Lincoln School, New York, N. Y., Ed21-28, D29, 30, 31.
Congdon, Allan R., Univ. of Nebraska, Lincoln, Nebr., V-P34, 35, D41, 42, 43.
Daly, Winnie D., Sophie B. Wright H. S., New Orleans, La., V-P25.
Dice, Elizabeth S., North Dallas H. S., Dallas, Texas, D28, 29, 30, 31.
Downey, Walter F., English H. S., Boston, Mass., D28, 29.
Eells, Walter C., Whitman College, Walla Walla, Wash., D23, 24, 25.
*English, Harry, Franklin School, Washington, D. C., D25, 26, 27, 28, 29, 31. Died 8 June '33.
Everett, John P., State Teachers College, Kalamazoo, Mich., P30, 31, D32, 33, 34.
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Garland, Harold B., H. S. of Commerce, Boston, Mass., D45, 46, 47.
Gugle, Marie, Asst., Supt. Columbus, Ohio, D20, 21, 22, P26, 27, D28, 29, 30, 31, 32, 33.
Haertter, Leonard D., John Burrough School, Clayton, Mo., D36, 37, 38.
Hart, Walter W., Univ. H. S., Madison, Wis., V-P26.
Hartung, Maurice L., Wisconsin H. S., Madison, Wis., D35, 36, 37, 38, 39, 40.
Hassler, J. O., Univ. of Oklahoma, Norman, Okla., D28, 29, 30, 31, 33, P34, 35, D41, 42, 43.
Hawkins, George E., Lyons Twp. H. S., LaGrange, Ill., D45, 46, 47.
Hildebrandt, Martha, Proviso Twp. H. S., Maywood, Ill., V-P31, 32, D34, 35, P36, 37, D38, 39.
Hildebrandt, E. H. C., Northwestern Univ., Evanston, Ill., D44, 45, 46.
Holroyd, Ina E., Kansas State College, Manhattan, Kan., D41, 42, 43.
Johnson, Elsie Parker, High School, Oak Park, Ill., D32, 33, 34.
Johnson, John T., Chicago Normal College, Chicago, Ill., V-P37-38.

*Kelly, Mary, Wichita H. S., East, Wichita, Kans., D32, V-P36, 37. Died 10 Aug. '41.
Lane, Ruth I., Univ. H. S., Iowa City, Iowa, V-P38, 39.
Mallory, Virgil S., State Teachers College, Montclair, N. J., D36, 37, 38, 39, 40, 41.
Miller, A. Brown, West Tech. H. S., Cleveland, Ohio, D39, 40, 41, 42, 43, 44.
Miller, Florence Brooks, Shaker Jr. H. S., Shaker Heights, Ohio, V-P35, 36
Minnick, John H., University of Penna., Philadelphia, Pa., P21, 22, 23.
Morton, Robert L., Ohio University, Athens, Ohio, V-P41, 42.
Olds, Edwin G., Carnegie Inst. of Tech., Pittsburgh, Pa., V-P43, 44.
Poole, Hallie S., Lafayette H. S., Buffalo, N. Y., V-P29, 30.
Potter, Mary A., Superv. of Math., Racine, Wis., V-P32, 33, D35, 36, 37, P41, 41.
Rankin, William W., Duke University, Durham, N. C., D22, 23, 24.
Reeve, William D., Teachers College, Columbia Univ., N. Y., D20, 26, 27, Ed. 28-.
Rorer, Johnathan T., William Penn H. S., Philadelphia, Pa., D20, 21.
Rugg, Harold O., Lincoln School, New York, N. Y., V-P20.
Sabin, Mary S., East H. S., Denver, Colo., V-P28, 29, D30, 31, 32, 33.
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Smith, Rolland R., Public Schools, Springfield, Mass., D35, 36, 37, 38, 39, 40, P42, 43.
Stokes, Ruth W., Winthrop College, Rock Hill, S. C., D44, 45, 46.
Sykes, Mabel, Bowen High School, Chicago, Ill., V-P23.
Taylor, Edson H., State Teachers College, Charleston, Ill., V-P21.
Thiele, C. Louis, Public Schools, Detroit, Mich., D31, 32, 33.
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Weeks, Eula A., Cleveland H. S., St. Louis, Mo., V-P22, D23, 24, 25.
Wheeler, Dorothy S., Bulkeley H. S., Hartford, Conn., D39, 40, 41, V-P42, 43.
Wheeler, A. Harry, North H. S., Worcester, Mass., D20, 21.
Whitcraft, Leslie H., Ball State Teachers College, Muncie, Ind., D41, 42, 43, V-P45, 46.
Woolsey, Edith, Sanford Jr. H. S., Minneapolis, Minn., D34, 35, 36, 37, 38, 39, V-P44, 45.
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Wren, F. Lynwood, Peabody College, Nashville, Tenn., V-P40, 41, P44, 45.

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The student should distrust his knowledge of any physical idea which he is not able to reduce to quantitative terms.—A. A. KNOWLTON